FINAL REPORT
ROUND 10 DAM ASSESSMENT
PPL GENERATION, LLC.
BRUNNER ISLAND POWER STATION
ASH BASIN NO. 6 WITH POLISHING POND, EQUALIZATION POND AND INCIDENTAL WASTE TREATMENT BASIN (IWTB)
YORK HAVEN, PENNSYLVANIA

DECEMBER 20, 2012

PREPARED FOR:

U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

PREPARED BY:

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GZA File No. 01.0170142.30

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GeoEnvironmental, Inc.

Engineers and Scientists

December 20, 2012
GZA File No. 170142.30

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U.S. Environmental Protection Agency
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Washington, DC 20460

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Dear Mr. Hoffman,

In accordance with our proposal 01.P0000177.11 dated March 28, 2011, and U.S. Environmental Protection Agency (EPA) Contract No. EP10W001313, Order No. EP-B115-00049, GZA GeoEnvironmental, Inc. (GZA) has completed our inspection of the Pennsylvania Power and Light (PPL) Brunner Island Power Station Ash Basin No. 6, Incidental Waste Treatment Basin (IWTB), and the Equalization Pond, located in York Haven, Pennsylvania. The Site visit was conducted on May 18, 2011. The purpose of our efforts was to provide the EPA with a site specific inspection of the impoundments to assist EPA in assessing the structural stability of the impoundments under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 104(e). We are submitting one hard copy and one CD-ROM copy of this Final Report directly to the EPA.

The IWTB and Equalization Pond do not meet the criteria set forth by the U.S. EPA with regard to coal ash impoundments. These structures were inspected during the site visit and checklists included in **Appendix C**, however no further study or discussion of the IWTB and Equalization Pond is necessary.

Based on our visual inspection, follow-on supporting engineering analyses provided by PPL, and in accordance with the EPA criteria, the Ash Basin No. 6 is judged to be in **FAIR** condition, in our opinion. Further discussion of our evaluation and recommended actions are presented in the Task 3 Dam Assessment Report. The report includes: (a) a completed Coal Combustion Dam Inspection Checklist Form for each Basin; (b) a field sketch; and (c) selected photographs with captions. Our services and report are subject to the Limitations found in **Appendix A** and the Terms and Conditions of our contract agreement.

We are happy to have been able to assist you with this inspection and appreciate the opportunity to continue to provide you with dam engineering consulting services. Please contact the undersigned if you have any questions or comments regarding the content of this Task 3 Dam Assessment Report.

Sincerely,

GZA GeoEnvironmental, Inc.

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PREFACE

The assessment of the general condition of the dam reported herein was based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations were beyond the scope of this report.

In reviewing this report, it should be realized that the reported condition of the dam was based on observations of field conditions at the time of inspection, along with data available to the inspection team. In cases where an impoundment is lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions, which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is critical to note that the condition of the dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the reported condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Prepared by:

GZA GeoEnvironmental, Inc.

COMMONWEALTH OF PENNSYLVANIA
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EXECUTIVE SUMMARY

This Inspection Report presents the results of a visual inspection of the PPL Generation, LLC. (PPL) – Brunner Island Power Station Coal Combustion Waste (CCW) Impoundments located at Wago Road, York Haven, Pennsylvania. These inspections were performed on May 18, 2011 by representatives of GZA GeoEnvironmental, Inc (GZA), accompanied by representatives of PPL, the Pennsylvania Department of Environmental Protection (PADEP) Dam Safety and Waste Management.

Brunner Island Power Station is a three unit coal fired power plant with a maximum generating capacity of approximately 1,490 Megawatts. Unit 1 began operation in 1961 and units 2 and 3 became operational in 1965 and 1969, respectively. At the time of the inspection there were three active impoundments at the site. Two of the impoundments, the Incidental Waste Treatment Basin (IWTB) and the Equalization Basin, do not meet the criteria set forth by the U.S. EPA for coal ash impoundments. The IWTB, designed in 1972, impounds and treats surface water runoff from the raw coal storage pile north of the power station. The Equalization Basin, designed in 1992, impounds surface water runoff and incidental station waste flows from station processes. Small amounts of CCWs may be present in the waste flows entering the Equalization Basin, in particular from the dry storage silo was area, although quantities are considered minimal. Waste water is pumped from the Equalization Basin to the Ash Basin No. 6. ***Both the IWTB and Equalization Basin were inspected during the site visit and checklists have been included in Appendix C, however no further study or discussion herein in this report for the IWTB and Equalization Basin is necessary.***

Ash Basin No. 6 was designed in 1979 for the purpose of storing CCWs pumped into the basin as water slurry. The basin is filled via ash lines at the northeast and northwest corners. Ash is allowed to settle from the slurry for storage and beneficial reuse. Water is treated for pH entering the Polishing Pond, prior to discharging in the Susquehanna River. The Polishing Pond is considered part of the Ash Basin No. 6, however for further detail a separate checklist was performed during the site visit which is attached in **Appendix C**. Station waste waters are also pumped to the Ash Basin No. 6 from the Equalization Basin, entering the basin at the northeast corner.

Ash Basin No. 6 in its current configuration has a maximum embankment height of approximately 30 feet to natural ground and an original storage volume of approximately 2,600 acre-feet at the top of embankment. Therefore in accordance with USACE criteria the Ash Basin No. 6 is classified as an **Intermediate** sized structure. According to guidelines established by the U.S. Army Corps of Engineers dams with a storage volume between 1,000 and 50,000 acre-feet and/or a height between 40 and 100 feet are classified as Intermediate sized structures. It is noted that the State of Pennsylvania uses the same classification guidelines as the USACE. Under the PADEP guidelines the dam is classified as a **Class B** structure (Intermediate).

In GZA's opinion, Ash Basin No. 6 is a **Significant** Hazard Structure as classified under the Environmental Protection Agency (EPA) hazard rating criteria. The hazard potential rating is based on GZA's opinion that failure of the embankment is not likely to result in loss of human life, and there is limited habitation adjacent to the basin. However a sudden uncontrolled release could cause environmental damage and economic loss to the adjacent Susquehanna River and adjacent rural land area.

GZA's visual inspection indicated the overall condition of Ash Basin No. 6 to generally be in FAIR condition. However, based on EPA's inspection criteria, the impoundment was initially assigned a **POOR** Condition Rating in GZA's Draft Report, because complete hydraulic and hydrologic analyses/computations and geotechnical computations (rapid drawdown analysis) were not provided/available for GZA's review. Thus, the ability of the structure to safely pass the design storm and the stability of the embankment(s) could not be independently verified. Since issuance of the Draft Report, PPL has provided hydraulic, hydrologic and geotechnical analyses/computations in satisfaction of EPA's inspection criteria. These analyses were reviewed by GZA and support our opinion that a condition rating of **FAIR** is justified at this time. The following deficiencies were noted at the CCW impoundment, Ash Basin No. 6:

1. Overgrown vegetation, up to 36 inches high, at outside embankment slopes and portions of inside embankment slopes. Overgrown vegetation may obscure potential detrimental embankment conditions.
2. Ruts and depressions observed at portions of the embankment toe from vehicles.
3. Saturated portions of embankment and standing water observed at the toe of dam at various locations around the Polishing Pond and east embankment. Conditions possibly due to heavy rainfall over the prior week. According to PPL personnel waters of the Susquehanna River had recently receded from the areas surrounding the toe of the embankment, which may also have contributed to the standing water and saturated conditions.
4. Sloughing observed at inside slope of the Polishing Pond, especially near the water line at the east side. Sloughs and scarps observed generally less than 3 feet deep.
5. Erosion from surface water runoff observed at the inside face of the Polishing Pond near the north end.
6. Approximately 40 foot long section of spongy/soft soil observed the east embankment near the south side from the toe to approximately 1/3 the height of the embankment. Note this condition was also reported on previous inspection reports by HDR Engineering, Inc.
7. Minor depressions and erosion observed at the crest.
8. 10 to 15 foot wide slough/scarp at the east embankment approximately 75 feet south of the access stairway on the outside face.
9. Large stock pile of top soil adjacent to the west embankment slope just north of the electric wire stanchion, possibly surcharging the embankment.

Studies and Analyses:

1. Investigate cause of spongy/soft ground observed at the east embankment.

Operations and Maintenance Activities:

1. Maintain grass cover on the downstream slope and approximately 15 feet beyond the toe area. USACE recommends vegetation be kept less than 12 inches in height on embankments. This may required mowing more frequently than bi-annually.

2. Fill ruts, depressions, and animal burrows and reseed if necessary.

3. Monitor and repair sloughing at the inside slope at the Polishing Pond and outside slope at the east embankment, or other locations sloughing is observed.

4. Exercise stoplogs and slide gates at least once annually.

5. Monitor spongy/soft ground observed at the east embankment.

Minor Repairs:

1. Repair sloughs and scarps on the embankment and provide future erosion protection as necessary.

Remedial Measures:

1. In conjunction with the results of the updated hydrologic and hydraulic analyses, make provisions for an emergency overflow spillway.

It should be noted that during the over the 12 months time since the filing our Draft Report and receipt of comments from the EPA thereon, it is GZA's understanding that PPL is still in the process of taking steps to permanently close the Basin. According to the comments received on our Draft Report, GZA understands that PPL will be submitting closure plan permit applications to PADEP very shortly and will commence dewatering once they have the necessary PADEP approval. In the interim, GZA's opinion is that it would be prudent for PPL to at least implement the above recommended Operations and Maintenance and Minor Repair Recommendations. We acknowledge that implementation of some of the above studies and analyses and remedial measures recommendations may not be critical given the current permanent closure plans. However in keeping with good engineering practice and as recommended in HDR's October 30 2012 memorandum, it would be expected that deficiencies regarding the embankments (if any) would be appropriately addressed in the closure plan if the dikes are to remain unbreached in the permanently closed condition.

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1.0 DESCRIPTION OF PROJECT

1.1 General

1.1.1 Authority

The United States Environmental Protection Agency (EPA) has retained GZA GeoEnvironmental, Inc. (GZA) to perform visual inspections and develop a report of conditions for the PPL Generation, LLC. (PPL, Owner) Brunner Island Power Station, Coal Combustion Waste (CCW) impoundments in York Haven, Pennsylvania. These inspections were authorized by the EPA under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 104(e). These inspections and report were performed in accordance with Task 3 of RFQ-DC-16 Round 10 for EPA's Office of Resource Conservation and Recovery in support for the Assessment of Dam Safety of Coal Combustion Surface Impoundments, dated March 16, 2011. The inspection generally conformed to the requirements of the Federal Guidelines for Dam Safety[1], and this report is subject to the limitations contained in **Appendix A** and the Terms and Conditions of our Contract Agreement.

1.1.2 Purpose of Work

The purpose of this investigation was to visually inspect and evaluate the present condition of the dam, dikes and appurtenant structures to attempt to identify conditions that may adversely affect their structural stability and functionality, to note the extent of any deterioration that may be observed, review the status of maintenance and needed repairs, and to evaluate the conformity with current design and construction standards of care.

The investigation was divided into four parts: 1) obtain and review available reports, investigations, and data from the Owner pertaining to the dam and appurtenant structures; 2) perform an on site review with the Owner of available design, inspection, and maintenance data and procedures for the management unit(s); 3) perform a visual inspection of the site; and 4) prepare and submit a draft and a final report presenting the evaluation of the structure, including recommendations and proposed remedial actions.

1.1.3 Definitions

To provide the reader with a better understanding of the report, definitions of commonly used terms associated with dams are provided in **Appendix B**. Many of these terms may be included in this report. The terms are presented under common categories associated with dams which include: 1) orientation; 2) dam components; 3) size classification; 4) hazard classification; 5) general; and 6) condition rating.

[1] FEMA/ICODS, April 2004: http://www.ferc.gov/industries/hydropower/safety/guidelines/fema-93.pdf

1.2 Description of Project

1.2.1 Location

Brunner Island Power Station is located approximately 15 miles southeast of Harrisburg, Pennsylvania. The power station is accessible from the North via Route 382 off Interstate Highway I-83. Ash Basin No. 6 and associated Polishing Pond are located approximately 1.5 miles south of the power station. The Incidental Waste Treatment Basin (IWTB) and Equalization Basin are located adjacent to the power station to the northeast and southeast, respectively. Brunner Island Power Station is approximately located at latitude 40° 05' 46" N and longitude 76° 41' 46" West. A site locus of the impoundments and surrounding area is shown in **Figure 1**. An aerial photograph of the impoundments and surrounding area is provided in **Figure 2**. The impoundments can be access by vehicles via, asphalt paved and gravel paved roads from Wago Road.

1.2.2 Owner/Caretaker

The basins and power station are owned and operated by the PPL Generation, LLC.

	Dam Owner/Caretaker
Name	PPL Generation, LLC[2]
Mailing Address	Two North Ninth Street
City, State, Zip	Allentown, PA 18101-1179
Contact	Craig S. Shamory
Title	Environmental Supervisor
E-Mail	csshamory@pplweb.com
Daytime Phone	(610)774-5653
Emergency Phone	911

1.2.3 Purpose of the Basins

Brunner Island Power Station is a three unit coal fired power plant with a maximum generating capacity of approximately 1,490 Megawatts. Unit 1 began operation in 1961 and units 2 and 3 became operational in 1965 and 1969, respectively. At the time of the inspection there were three active impoundments at the site. Two of the impoundments, the Incidental Waste Treatment Basin (IWTB) and the Equalization Basin, do not meet the criteria set forth by the U.S. EPA for coal ash impoundments. The IWTB, designed in 1972, impounds and treats surface water runoff from the raw coal storage pile north of the power station. The Equalization Basin, designed in 1992, impounds surface water runoff and incidental station waste flows from station processes. Small amounts of CCWs may be present in the waste flows entering the Equalization Basin, in particular from the dry storage silo wash area, although quantities are considered minimal. Waste water is then pumped from the Equalization Basin to the Ash Basin No. 6. ***Both the IWTB and Equalization Basin were inspected during the site visit and checklists have been included in* Appendix C, *however no***

[2] PPL Generation, LLC is PPL Corporation Company.

further study or discussion herein in this report for the IWTB and Equalization Basin is necessary.

Ash Basin No. 6 was designed in 1979 for the purpose of storing CCWs pumped into the basin as water slurry. The basin is filled via ash lines at the northeast and northwest corners. Ash is allowed to settle from the slurry for storage and beneficial reuse. Water is treated for pH entering the Polishing Pond, prior to discharging into the Susquehanna River. The Polishing Pond is considered part of the Ash Basin No. 6, however for further detail a separate inspection checklist was performed during the site visit which is attached in **Appendix C**. Station waste waters are also pumped to the Ash Basin No. 6 from the Equalization Basin, entering the basin at the northeast corner.

According PPL personnel all bottom ash, which formerly went to Ash Basin No. 6, now goes to a "concrete bottom ash sluice trough/pond" tank constructed, approximately 2 to 3 years prior to this inspection, for the purpose of removing and collecting bottom ash for beneficial reuse. Ash Basin No. 6 at the time of this inspection still received water from the Equalization Basin and residual treatment water from the bottom ash sluice trough/pond. At the time of this inspection PPL was in the process of constructing a waste water treatment facility, which when completed will treat the residual water currently sent to Ash Basin No. 6 from the Equalization Basin and bottom ash sluice trough/pond. Upon completion of the treatment plant discharge into Ash Basin No. 6 will be ceased and closure of Ash Basin No. 6 will begin. PPL personnel estimate closure of the basin may begin in approximately 1 to 1.5 years from the date of this inspection.

1.2.4 Description of Ash Basin No. 6 Embankments and Appurtenances

The following description of the Ash Basin No. 6 and associated Polishing Pond is based conversations with PPL personnel, design drawings, previous inspection reports, and field observations by GZA.

Ash Basin No. 6 was designed by Pennsylvania Power and Light Company of Allentown Pennsylvania in 1979. The Basin is formed of an approximately 8,300 foot long perimeter embankment creating a 70-acre impoundment. Originally the basin had a storage capacity of approximately 2,600 acre-ft and a height from the top of embankment (EL. 290 feet) to natural ground of approximately 30 feet (outside slope) and a depth of approximately 39 feet from the top of embankment to the bottom of the basin (inside slope). The Embankments are constructed of native sandy silt and silty clay[3] with a 10-foot thick clay liner at the inside face from elevation 287.5 feet to bedrock. Based on our interpretation of the record information provided by PPL, it does not appear as though Ash Basin No. 6 was constructed over wet ash, slag, or other unsuitable materials. At the time of the inspection it is estimated, due to infilling, the pool area was about 11 acres.

Ash lines enter the basin from the northeast and northwest corners. The ash-line at the northeastern corner of the basin formerly carried CCWs from Unit 3 however now only carries water pumped from the equalization basin from surface water runoff and incidental plant waste flows. The effluent can carry fly ash from the dry storage silo wash area, however any amounts are typically minimal. Ash lines entering the northwest corner formerly carried CCWs from Units 1 & 2. CCWs from those units are now processed separately. According to

[3] From "Slope Stability Assessment Brunner Island Ash Basin No. 6" by HDR Engineering, Inc. 2009.

PPL personnel approximately 2 to 3 years prior to the date of this inspection a concrete "bottom ash sluice trough/pond" tank was constructed to settle and remove bottom ash, from units 1 & 2. Residual water from this process may still be pumped to the northwest corner of Ash Basin No. 6. At the time of this inspection PPL was in the process of constructing a waste water treatment facility, which when completed will treat the residual water currently sent to Ash Basin No. 6 and permit closure of the basin.

Two dikes split the Ash Basin No. 6 into three sub-basins. The "median dike" used to control suspended solids when fly ash was being discharged had a crest width of 15 feet and 3H:1V north and south slopes. Originally twenty 12-inch uncontrolled pipes allowed water to pass through the embankment into the central basin, however the dike has since been breached, near the middle, to improve flow. At the time of the inspection the northern basin was almost completely filled in, though waste water is still routed through this area.

A second dike, at the southern end of the impoundment, separates the central sub-basin from the Polishing Pond. The dike was constructed similarly to the outer embankments however both the north and south slopes have approximately 10-foot thick clay liners. Discharge through the dike to the Polishing Pond is via a 10-foot wide stoplog weir drop inlet, which joins a 48-inch concrete culvert and sluiceway. Water discharging from the central sub-basin to the Polishing Pond may be treated (if necessary) by treatment facilities housed on the dike.

Water exits the Polishing pond via two 60-inch diameter reinforced concrete drop inlet pipes at the eastern side of the inside embankments which joins a 48-inch reinforced concrete pipe (RCP) prior to discharging into the Susquehanna River. A headwall and 48-inch flap valve resides at the downstream discharge to prevent rising river water from charging the impoundment.

1.2.5 Operations and Maintenance

The embankment and its impoundment are operated and maintained by PPL personnel. Operations of the basin are limited to operation of pumps discharging waste water into the basin, operation of stoplogs (if necessary), and control of the pH water treatment facility at the Polishing Pond. According to PPL personnel maintenance of the dam includes bi-annually mowing slopes and repairs to erosion and sloughs.

Operation and maintenance of the Ash Basin No. 6 is regulated by the EPA under the National Pollutant Discharge Elimination System (NPDES) Permit No. PA 0008281. The basin is also regulated by the PADEP Office of Dam Safety and the PADEP Bureau of Land Recycling and Waste Management. Quarterly visual inspections are performed for the Office of Dam Safety at the Ash Basin No. 6 as well as more detailed annual inspections as required by the impoundments General Permit.

Fly ash is collected and stored in silos and bottom ash slurry sent through a bottom ash sluice trough/pond, adjacent to the power station. It is the intent of PPL that all ash be collected and beneficially used. Formerly, when ash was being sluiced to the basin, bottom ash was collected and sorted by a series of conveyors and screens and marketed. Most of the ash sent to the basin was collected by dredging out of the channel at the ash marketing area.

1.2.6 Size Classification

For the purposes of this EPA-mandated inspection, the size of the dam and its impoundment will be based on United States Army Corps of Engineers (USACE) criteria. Ash Basin No. 6 in its current configuration has a maximum embankment height of approximately 30 feet to natural ground and an original storage volume of approximately 2,600 acre-feet at the top of embankment. Therefore in accordance with USACE criteria the Ash Basin No. 6 is classified as an **Intermediate** sized structure. According to guidelines established by the U.S. Army Corps of Engineers dams with a storage volume between 1,000 and 50,000 acre-feet and/or a height between 40 and 100 feet are classified as Intermediate sized structures. It is noted that the State of Pennsylvania uses the same classification guidelines as the USACE. Under the PADEP guidelines the dam is classified as a **Class B** structure (Intermediate).

The maximum dam height of approximately 30 feet is based on the height of the dam at the outside face from the crest to natural ground surface. Based upon original design drawings, the top of dam has an elevation of approximately 290 feet, and low point along the toe of the embankment is approximately 260 feet. This is consistent with the dam height reported by PPL's independent dam engineering consultant HDR Engineering, Inc. of Portland Maine (HDR) in their 2009 inspection report. Note that the inside face has an approximate height from the crest to bottom of basin of 39 feet.

1.2.7 Hazard Potential Classification

Under the EPA classification system, as presented on page 2 of the EPA check list (**Appendix C**) and Definitions section (**Appendix B**), it is GZA's opinion that the Ash Basin No. 6 is a **Significant** Hazard potential structure. The hazard potential rating is based on GZA's opinion that failure of the embankment is not likely to result in loss of human life, and there is limited habitation adjacent to the basin. Additionally it is noted that the majority of the 70 acre-sized impoundment has been filled with ash waste covered with soil, there is no contributing watershed and only approximately 11 acres has standing water. Nevertheless, given the height of the embankment, and the amount of water and ash stored therein, a sudden uncontrolled release could cause economic loss and environmental damage to the adjacent Susquehanna River or adjacent rural land. The area downstream of the dam is shown in **Figure 4**.

The Ash Basin No. 6 has been classified as a Category 3 hazard potential structure according to the PADEP Dam Safety Regulations. Failure of a Category 3 structure may lead to "significant" property damage and "no" loss of life if the dam were to fail.

1.3 Pertinent Engineering Data

1.3.1 Drainage Area

Based on the design documents and as estimated by GZA, Ash Basin No. 6 does not receive drainage from the surrounding areas. Water entering the basin is pumped from the Equalization Basin (entering northeast corner) and residual waste water from the bottom ash sluice trough/pond tank (entering the northwest corner). The only uncontrolled water that enters the impoundments is from direct precipitation. The estimated drainage area is shown in **Figure 3A**. Note as described in Section 1.2.4 CCWs are no longer sluiced into Ash Basin

No. 6 as they formerly were due to the construction of dry fly ash handling silos and the sluice trough/pond tank for bottom ash handling.

According to PPL personnel within approximately 1 to 1.5 years from the time of this inspection, the Ash Basin No. 6 will be closed and capped. Topsoil is being stockpiled at the impoundment currently.

1.3.2 Impoundment

The Ash Basin No. 6 has a surface area of approximately 70 acres and an original storage volume of 2,600 acre-feet at the top of embankment, elevation 290 feet. The basin is formed of an approximately 8,300 foot perimeter dike with an approximate height to natural ground of 30 feet and a depth from the top of embankment to the bottom of the basin of approximately 39 feet. Two intermediate dikes divide the basin into three sub-basins. The northern sub-basin was almost entirely silted in with ash at the time of this inspection and the center basin, was partially full. The southern basin, or polishing pond, is used for final clarification and pH treatment of water prior to being discharged into the Susquehanna River.

1.3.3 Discharges at the Dam Site

Plant waste water from the Equalization Basin and residual waste water from the bottom ash sluice trough/pond enter the impoundment at the northeast and northwest corners, respectively. Water flows south through the filled in north sub-basin through an approximately 12 to 20 foot wide channel[4] prior to entering the central sub-basin. The central sub-basin drains into the polishing pond and water treatment facility through a 10-foot wide stoplog weir drop inlet, which joins a 48-inch concrete culvert and sluiceway. Water exits the Ash Basin No. 6 Polishing Pond via two 60-inch diameter reinforced concrete drop inlet pipes at the eastern side of the inside embankments which joins a 48-inch reinforced concrete pipe (RCP) prior to discharging into the Susquehanna River. A headwall and 48-inch flap valve resides at the downstream discharge to prevent rising river water from charging the impoundment.

Formerly when CCWs were being discharged into the impoundment, discharges had been as high as 15 million gallons per day (MGD). Flows at the time of inspection were significantly smaller.

1.3.4 General Elevations (feet)

Elevations are from design drawings, reports and data provided by PPL.

A.	Top of Dam (Minimum)	290 ± feet
B.	Spillway Design Flood Pool (Design)	Unknown
C.	Low Point along Toe of Dam	± 260 feet
D.	Downstream Tail Water at Time of Inspection	± 252 feet

[4] Channel width estimated by Google Earth.

Central Sub-Basin:

A.	Normal Pool	287 feet
B.	Spillway Crest	286.25 feet[5]
C.	Pool at Time of Inspection	± 286.5 feet

Polishing Pond:

A.	Normal Pool (Polishing Pond)	268 feet
B.	Spillway Crest	268 feet
C.	Pool at Time of Inspection	± 268 feet

1.3.5 Spillway Data

Central Sub-Basin:

A.	Type	Concrete stoplog weir
B.	Weir Length	10 feet 48-inch RCP & Sluiceway
C.	Weir Crest/Control Elevation	287 feet

Polishing Pond:

A.	Type	RCP Drop Inlets
B.	Diameter	60-inches (Two) Joining a; 48-inch RCP Outlet
C.	Weir Crest/Control Elevation	268 feet

1.3.6 Design and Construction Records and History

The Ash Basin No. 6 was designed by Pennsylvania Power and Light Company approximately 1979. Subsurface explorations were performed at the site in February and March of 1975 and January and February of 1977. Bedrock was encountered between approximate elevations 242 and 252 feet and according to a report for Pennsylvania Power and Light Company bedrock conditions consisted of the following:

Triassic Age New Orford formation which consists of light colored sandstone, conglomeratic sandstone, red to purplish red sandstone, shale and mudstone… The rock is highly fractured as a result of its vertical joint pattern which is very closely spaced, moderately developed and open.[6]

Embankments were constructed of native sandy silt and silty clay identified during the subsurface explorations and excavated as part of the basin construction. An approximately 10 foot thick relatively impermeable clay liner was also constructed at the inside face from elevation 287.5 feet to bedrock.

[5] One level of stoplogs removed in 2009, lowering the weir crest approximately 9 inches.

[6] Report on Investigation of Foundation Conditions for Ash Storage Basins 6 and 7 Brunner Island S.E.S., Prepared by Borings, Soils & Testing Company, Harrisburg, PA for Pennsylvania Power and Light Company.

According to PPL personnel approximately 2 to 3 years prior to the date of this inspection a concrete bottom ash sluice trough/pond tank was constructed for the purpose of removing and collecting bottom ash CCWs prior to reaching the Ash Basin No. 6. Dry fly ash precipitators and silos also remove fly ash CCWs for beneficial reuse. Residual water from the bottom ash and fly ash treatment facilities at the time of this inspection was pumped to Ash Basin No. 6. A waste water treatment facility was under construction at the time of this inspection adjacent to the sluice trough/pond tank, which will treat residual water from the CCW collection facilities, eliminating discharges into the Ash Basin No. 6. Upon completion of the residual waste water treatment facility, PPL intends to terminate all discharges into and close Ash Basin No. 6. PPL estimates closure of the basin may begin in 1 to 1.5 years from the date of this inspection. Final cover soil was observed stockpiled at the north sub-basin (filled in) and is reportedly from farmland previously owned by PPL which is currently being developed into a golf course. Approximately 1 foot of clay (or synthetic liner), drainage layer, and two feet of soil are proposed to create an impermeable cap for the basin.

In 2009, stability analyses were performed by HDR. As part of the investigation four open standpipe piezometers were installed (B09-1 to B09-4). Refer to Section 2.6 below for additional discussion of the results of this study.

1.3.7 Operating Records

No operating records were available for GZA to review at the time of this inspection.

1.3.8 Previous Inspection Reports

Quarterly visual inspections are performed for the Office of Dam Safety at the Ash Basin No. 6 as well as more detailed annual inspections as required by the impoundments General Permit. The two most recent annual inspections of the dam, by HDR were conducted on November 4, 2009 and December 17, 2010. A summary of recommendations from the 2009 report are as follows:

- Continue regular maintenance of the slopes including mowing, repairing sloughs, and plan vegetation cutting beyond the toe.
- Eradicate burrowing animals and fill burrows whenever they are encountered in the embankment or within 50 feet of the toe.
- Address historic slope sloughing and wet areas on the embankments as well as address the recommendations for slope stability by HDR.
- PPL staff should monitor discharge levels to verify no constrictions occur upstream of the discharge points into the Ash Basin No. 6.
- Investigate the effect of the broken corrugated metal pipe and joint in the sedimentation basin at the northwest corner of the basin on seepage observed at the toe.
- Investigate the 2 to 3 foot high diversion dike on the interior of the basin at the northeast corner and the possibility of it retaining ash and water. Installation of a monitoring and/or warning system is recommended.

PPL continues to mow embankments bi-annually. Actions to remediate slope stability deficiencies have not yet been undertaken, however at the time of the inspection PPL was further investigating slope stability concerns and seepage recommendations.

2.0 INSPECTION

2.1 Visual Inspection

Ash Basin No. 6 was inspected on May 18, 2011 by Brad Nourse and James P. Guarente, P.E. of GZA GeoEnvironmental, Inc. At the time of the inspection the weather was cloudy with occasional rain and temperatures in the 60°s Fahrenheit. Photographs to document the current conditions of the embankments were taken during the inspection and are included in **Appendix D**. At the time of the inspection the water level in Ash Basin No. 6 was approximately 286.5 feet, based on stop log settings. Underwater areas were not inspected, as this level of investigation was beyond that of GZA's scope of services. Copies of the EPA checklists are included in **Appendix C**. For additional detail a separate inspection checklist for the Polishing Pond has been provided.

With Respect to our visual inspection there was no evidence of prior releases or failures observed by GZA.

2.1.1 Ash Basin No. 6 General Findings

In GZA's Draft Report the Ash Basin No. 6 was found to be in POOR condition primarily due to inadequate factors of safety for the rapid drawdown condition, which exists for downstream embankment slopes that are in close proximity to the Susquehanna River as reported by HDR during their 2009 stability analysis, and the lack of sufficient hydrologic and hydraulic analyses confirming that there was adequate available storage in the Basin and Polishing Pond under PADEP Dam Safety Regulations for this Class B-3 structure. Since issuance of the Draft Report however, PPL has provided hydraulic, hydrologic and geotechnical analyses/computations in satisfaction of EPA's inspection criteria. These analyses were reviewed by GZA and support our opinion that a condition rating of **FAIR** is justified at this time. An overall site plan showing the Ash Basin No. 6 and associated Polishing Pond is provided as **Figure 5A**. The location and orientation of photographs provided in Appendix D is shown on the Photo Location Plan in **Figure 6A and 6B**. The specific concerns are identified in more detail in the sections below.

The IWTB and the Equalization Basin, do not meet the criteria set forth by the U.S. EPA for coal ash impoundments as described in Section 1.2.3. ***Both the IWTB and Equalization Basin were inspected during the site visit and checklists have been included in*** **Appendix C,** ***however no further discussion is provided below.*** Photographs, site sketches, and figure have been included for the IWTB and Equalization Basin for reference.

2.1.2 East Embankment

The East embankment generally appeared to be in fair condition. Grass and vegetation was overgrown at the outside slope and was approximately 12 to 36 inches in height (Photos 6 & 12). Standing water was observed at the toe, however heavy rains from the week prior to the inspection and recently high river levels from the Susquehanna may have contributed to the conditions at the toe (Photo 13). An approximately 40 foot wide spongy/soft area of ground was noted at the southern portion near the Polishing Pond to approximately 1/3 up the embankment, no movement was noted. A scarp was observed at the downstream toe approximately 75 feet south of the stairs from the crest (Photo 14).

The crest of the west embankment consisted of a crushed stone travel way. Minor depressions and ruts were noted a various locations along the crest (Photo7).

A corrugated metal pipe was observed approximately 100 feet south of the access stairs on the outside east embankment slope (Photo 15). This appears to be a remnant discharge structure for a sedimentation basin used during the construction of the Ash Basin No. 6. Reportedly another exists at the West Embankment, however this was not observed by GZA during this inspection.

2.1.3 West Embankment

The West embankment generally appeared to be in fair condition. Overgrown vegetation approximately 12 to 36 inches in height was observed at the outside slope.

The crest of the west embankment consisted of a crushed stone travelway. Minor depressions and ruts were noted a various locations along the crest.

Stockpiles of top soil, for use during basin closure, were observed within the filled portion of the basin adjacent to the embankment. Material stockpiled close to an embankment may surcharge the embankment and put undue stress on it.

2.1.4 North Embankment (Photos 16, 17, & 19)

The north embankment separates Ash Basin No. 5 (closed) and Ash Basin No. 6. Most of the embankment crest is paved except at its east and west ends where the embankment crest is crushed stone. Both sides of the embankment are filled. Discharge pipes enter the basin at the northeast and northwest corners of the basin.

2.1.5 South Embankment (Polishing Pond)

Generally the Polishing Pond appeared to be in fair condition at the time of our inspection. Vegetation was observed to be overgrown to approximately 12 to 36 inches in height at both the inside and outside slopes, possibly obscuring deficiencies. Standing water and tire tracks/ruts were observed at the toe of slope near the southern most side and close to the new gate vault (Photos 31 & 32). According to PPL personnel, heavy rains and recently receded river levels may have contributed to abnormally wet conditions at the toe. A concrete patch was observed at the eastern side of the outside embankment (Photo 30), possibly a repaired seep or slough. PPL personnel on-site did not know the purpose of the concrete patch.

Several minor sloughs and scarps were observed near the waterline at the east side near the two 60-inch drop inlets and minor erosion at the downstream face of the southern separation dike (Photo 27). These sloughs appeared to be shallow (less than three feet deep). Stone and riprap was observed at the western side of the inside slope (Photo 26).

The crest generally appeared to be in satisfactory condition. Some depressions and tire tracks were noted from regular maintenance traffic.

2.1.6 Discharge Pipes and Decant Outflow Structures

Discharge pipes enter northeast and northwest corners of the Ash Basin No. 6. Waste water flow from the northeast discharge pipe is due to plant waste water flow pumped from the Equalization Basin and was flowing at the time of inspection (Photo 17). Water flows south in a discharge channel approximately 12 to 20 feet in width, through the filled in north sub-basin and joins with flow from the northwest corner prior to flowing into the central sub-basin. Discharge from the northwest corner is from residual waste water from the concrete bottom ash sluice trough/pond. At the time of the inspection discharge water appeared to contain CCWs (Photo 19). These pipes will be taken off line when the Ash Basin No. 6 is closed in 1 to 1.5 years according to PPL personnel.

Water from the central basin flows into the Polishing Pond and water treatment system via a 10 foot wide decant stoplog weir and 48-inch pipe and sluiceway. At the time of the inspection the water was at approximate elevation 286.5 feet in the central basin. The structure appeared to be in satisfactory condition at the time of this inspection. Winches, cable, and skimmer gates appeared to be in satisfactory condition (Photo 4).

The outlet structure from the Polishing Pond consists of two 60-inch drop inlets feeding into a 48 inch RCP (Photos 24 & 25). The 48-inch pipe leads to a new gate vault just downstream of the toe of slope and upstream of the discharge point to the Susquehanna River (Photos 28 & 32). The Vault was designed by Kleinschmidt in 2007. Water then discharges through a headway and 48-inch flap gate to an approximately 10 foot wide discharge channel to the Susquehanna River (Photos 33 & 34). The drop inlets and gate vault appeared to be in satisfactory condition at the time of the inspection. Some surface erosion was observed at the discharge headwall.

2.2 Caretaker Interview

GZA met with Craig Shamory of PPL during the site visit on May 18, 2011 and discussed the operations and maintenance procedures, regulatory requirements, and the history of the impoundments since their construction. The observations, descriptions and findings presented herein this report reference our discussions with Mr. Shamory.

Mr. Shamory indicated during the on-site inspection that neither the Ash Basin No. 6, or IWTB and Equalization Basin, had failed since their construction.

2.3 Operation and Maintenance Procedures

As discussed in Section 1.2.5, PPL personnel are responsible for the regular operations and maintenance of the basin.

2.4 Emergency Warning System

No emergency action plan has been prepared for the Ash Basin No. 6.

2.5 Hydrologic/Hydraulic Data

Initially, no hydrologic or hydraulic data was available for review by GZA at the time of this inspection. In the more than 12 months time since the filing our Draft Report and receipt of comments from the EPA thereon, PPL engaged HDR of Portland, ME to perform a Spillway Design Flood Analysis to verify that the Ash Basin can safely pass the Spillway Design Flood in accordance with PADEP regulations. Results of the study are presented in HDR's September 7, 2012 Engineering Report which has been attached as part of **Appendix E.** The report concluded that the main basin and polishing pond have sufficient discharge capacity to safely pass the SDF. The magnitude of the SDF for their analysis was the ½ PMF, pursuant to PADEP guidelines. HDR's analysis employed hydrologic storage routing methods, which incorporated conservative assumptions dealing with high tailwater conditions. In GZA's opinion the results appear to be conservative. These methods and computations included allowances for wind set up and wave run-up during the height of the design storm. While the results indicate a minimum freeboard ranging from 0.1 to 0.6 feet, this appears sufficient in GZA's opinion given the conservative nature of the analysis and the likely very high tailwater conditions occurring in the Susquehanna River. GZA did not perform an independent assessment of the hydraulics and hydrology for the basins as this was beyond the scope of our services.

2.6 Structural and Seepage Stability

2.6.1 Structural Stability

Field investigations and slope stability analysis were performed by HDR. A complete summary of parameters, loading conditions, and results are presented in their report entitled "Slope Stability Assessment Brunner Island Ash Basin No. 6" report by HDR dated December 2009 which is attached as part of **Appendix E**. The evaluation included four borings drilled at the east embankment; two at the crest and two at the downstream slope near the toe. HDR performed their stability analysis using the software UTEXAS4 and verified using SLOPE/W.

HDR's analysis indicated that for the normal and surcharge loading condition, the stability of the embankment was slightly below recommended values. HDR however considered this condition as satisfactory as per their interpretation of COE Manual EM 1110-2-1902 which states: *"Acceptable values of factors of safety for existing dams may be less than those for design of new dams, considering the benefits of being able to observe the actual performance of the embankment over a period of time."* GZA concurs with HDR's evaluation and is of the opinion that the reported factors of safety for the normal and surcharge loading conditions are reasonable given the adequate performance of the dam over time.

However factors of safety for the rapid drawdown condition were calculated by HDR to be less than the required minimum of 1.1 for the downstream embankment due to flooding from the Susquehanna River at the downstream slope during the 100 and 500-year floods. HDR therefore recommended (and GZA concurred in our August 31, 2011 Draft Report) that additional analyses could be performed to assess transient seepage conditions which may determine that a breach of the downstream embankment as a result of rapid drawdown would not occur. Otherwise they stated that remediation of the embankment would be warranted. GZA did not perform an independent assessment of the structural stability of the basins as this was beyond our scope of services.

In the almost 12 months time since the filing our Draft Report and receipt of comments from the EPA thereon, PPL engaged Schnabel Engineering of West Chester, PA to perform a transient study, including soil sampling and lab analysis to more thoroughly examine the Basin's dikes behavior under rapid drawdown conditions. Results of the study are presented in Schnabel's February 17, 2012 Geotechnical Engineering Report which has been attached as part of **Appendix E.** The report concluded that the dikes have an adequate factor of safety with respect to the rapid drawdown condition. Table 1 below presents a summary of the stability analyses performed, the actual value from each analysis conducted, and the minimum required Factor of Safety.

Table 1 – Stability Analyses Summary

SUMMARY OF STABILITY ANALYSIS BY HDR (December 2009)			
	Calculated Factor of Safety Against Deep Failure	Required Minimum Factor of Safety	Notes
Normal	1.41	1.5	2
Surcharge	1.31	1.4	2
10-yr Flood	1.14	1.1	1
100-yr Flood	1	1.1	1
500-yr Flood	1	1.1	1
Earthquake	1.2	1.2	
SUMMARY OF RAPID DRAWDOWN ANALYSIS BY SCHNABEL (February 2012)			
Rapid Drawdown (500-yr Flood)	1.13	1.1	

Notes:

1. Factors of Safety reported by HDR for the rapid drawdown conditions are superseded by the more sophisticated transient analyses performed by Schnabel Engineering.
2. Reported Factors of safety are below recommended values. However HDR considers these values as satisfactory for this structure based on their interpretation of COE Manual 1110-2-1902.

2.6.2 Seepage Stability

Seepage is controlled by a 10 foot thick clay liner at the inside face of the embankment from elevation 287.5 feet to bedrock. The Seepage analyses data presented in the hard copy of the Schnabel report provided for GZA review did not include calculated factors of safety with respect to seepage exit gradients as they relate to potential piping through the embankment. Piping is evaluated based on the calculated exit gradient compared to the critical gradient which is defined as the gradient level at which soil transport is assumed to begin. Taking the critical gradient as 1.0, as is typically done for sands, the safety factor against potential piping failure for existing site conditions is computed as:

$$F.S._{piping} = i_{cr} / i_{exit}$$

In general practice, the US Army Corps of Engineers document *Seepage Analysis and Control for Dams* – EM 1110-2-1901 dated 30 September 1986 refers to typically accepted recommended factor of safety against seepage failure are 4 to 5 (Harr, 1962, 1977) or 2.5 to

3.0 (Cedergren, 1977). Since seepage analysis is sometimes included as a preliminary step in building the transient model for the rapid drawdown analysis described in Section 2.6.1 above, GZA recommended that the Schnabel report be amended to include results of the seepage analyses and that factors of safety therefrom be compared with accepted minimums.

Schnabel's analysis however did not originally include an assessment of seepage gradients. Therefore in October 2012 PPL engaged HDR to evaluate the seepage and seepage gradients within the embankment. HDR's evaluation is presented in their October 30, 2012 memorandum which is also included in **Appendix E**. GZA reviewed HDR's memorandum and is of the opinion that the analysis, conclusions and recommendations therein coupled with the visual monitoring program that is in place at the facility constitutes a reasonable approach with respect addressing seepage behavior, particularly since PPL is in the process of permanently closing the basin.

GZA did not perform an independent assessment of the seepage stability of the basins as this was beyond our scope of services.

3.0 ASSESSMENTS AND RECOMMENDATIONS

3.1 Assessments

GZA's visual inspection indicated the overall condition of Ash Basin No. 6 to generally be in FAIR condition. However, based on EPA's inspection criteria, the impoundment was initially assigned a POOR Condition Rating in GZA's Draft Report, because complete hydraulic and hydrologic analyses/computations and geotechnical computations (rapid drawdown analysis) were not provided/available for GZA's review. Thus, the ability of the structure to safely pass the design storm and the stability of the embankment(s) could not be independently verified. Since issuance of the Draft Report, PPL has provided hydraulic, hydrologic and geotechnical analyses/computations in satisfaction of EPA's inspection criteria. These analyses were reviewed by GZA and support our opinion that a condition rating of **FAIR** is justified at this time. Additional deficiencies are noted as follows:

1. Overgrown vegetation, up to 36 inches high, at outside embankment slopes and portions of inside embankment slopes. Overgrown vegetation may obscure potential detrimental embankment conditions.
2. Ruts and depressions observed at portions of the embankment toe from vehicles.
3. Saturated portions of embankment and standing water observed at the toe of dam at various locations around the polishing pond and east embankment. Conditions possibly due to heavy rainfall over the prior week. According to PPL personnel waters of the Susquehanna River had recently receded from the areas surrounding the toe of the embankment, which may also have contributed to the standing water and saturated conditions.
4. Sloughing observed at inside slope of the Polishing Pond, especially near the water line at the east side. Sloughs and scarps observed generally less than 3 feet deep.
5. Erosion from surface water runoff observed at the inside face of the Polishing Pond near the north end.
6. Approximately 40 foot long section of spongy/soft soil observed at the east embankment near the south side from the toe to approximately 1/3 the height of the

embankment. Note this condition was also reported on previous inspection reports by HDR.

7. Minor depressions and erosion observed at the crest.
8. 10 to 15 foot wide slough/scarp at the east embankment approximately 75 feet south of the access stairway.
9. Large stock pile of top soil adjacent to the west embankment slope just north of the electric wire stanchion, possibly surcharging the embankment.

The following recommendations and remedial measures generally describe the recommended approach to address current deficiencies. Prior to undertaking recommended maintenance, repairs, or remedial measures, the applicability of environmental permits needs to be determined for activities that may occur within resource areas under the jurisdiction of the appropriate regulatory agencies.

3.2 Studies and Analyses

GZA recommends the following studies and analyses:

1. Investigate cause of spongy/soft ground observed at the east embankment.

3.3 Recurrent Operation & Maintenance Recommendations

GZA recommends the following operation and maintenance level activities:

1. Maintain grass cover on the downstream slope and approximately 15 feet beyond the toe area. USACE recommends vegetation be kept less than 12 inches in height on embankments. This may require mowing more frequently than bi-annually.

2. Fill ruts, depressions, and animal burrows and reseed if necessary.

3. Monitor and repair sloughing at the inside slope at the Polishing Pond and outside slope at the east embankment, or other locations sloughing is observed.

4. Exercise stoplogs and slide gates at least once annually.

5. Monitor spongy/soft ground observed at the east embankment.

3.4 Minor Repair Recommendations

GZA recommends the following minor repairs which may improve the overall condition of the basins, but do not alter their current design. The recommendations may require design by a professional engineer and construction contractor experienced in dam construction.

1. Repair sloughs and scarps on the embankment and provide future erosion protection as necessary.

3.5 Remedial Measures Recommendations

1. In conjunction with the results of the updated hydrologic and hydraulic analyses, make provisions for an emergency overflow spillway.

It should be noted that during the over the 12 months time since the filing our Draft Report and receipt of comments from the EPA thereon, it is GZA's understanding that PPL is still in the process of taking steps to permanently close the Basin. According to the comments received on our Draft Report, GZA understands that PPL will be submitting closure plan permit applications to PADEP very shortly and will commence dewatering once they have the necessary PADEP approval. In the interim, GZA's opinion is that it would be prudent for PPL to at least implement the above recommended Operations and Maintenance and Minor Repair Recommendations. We acknowledge that implementation of some of the above studies and analyses and remedial measures recommendations may not be critical given the current permanent closure plans. However in keeping with good engineering practice and as recommended in HDR's October 30 2012 memorandum, it would be expected that deficiencies regarding the embankments (if any) would be appropriately addressed in the closure plan if the dikes are to remain unbreached in the permanently closed condition.

3.6 Alternatives

There are no alternatives currently recommended.

4.0 ENGINEER'S CERTIFICATION

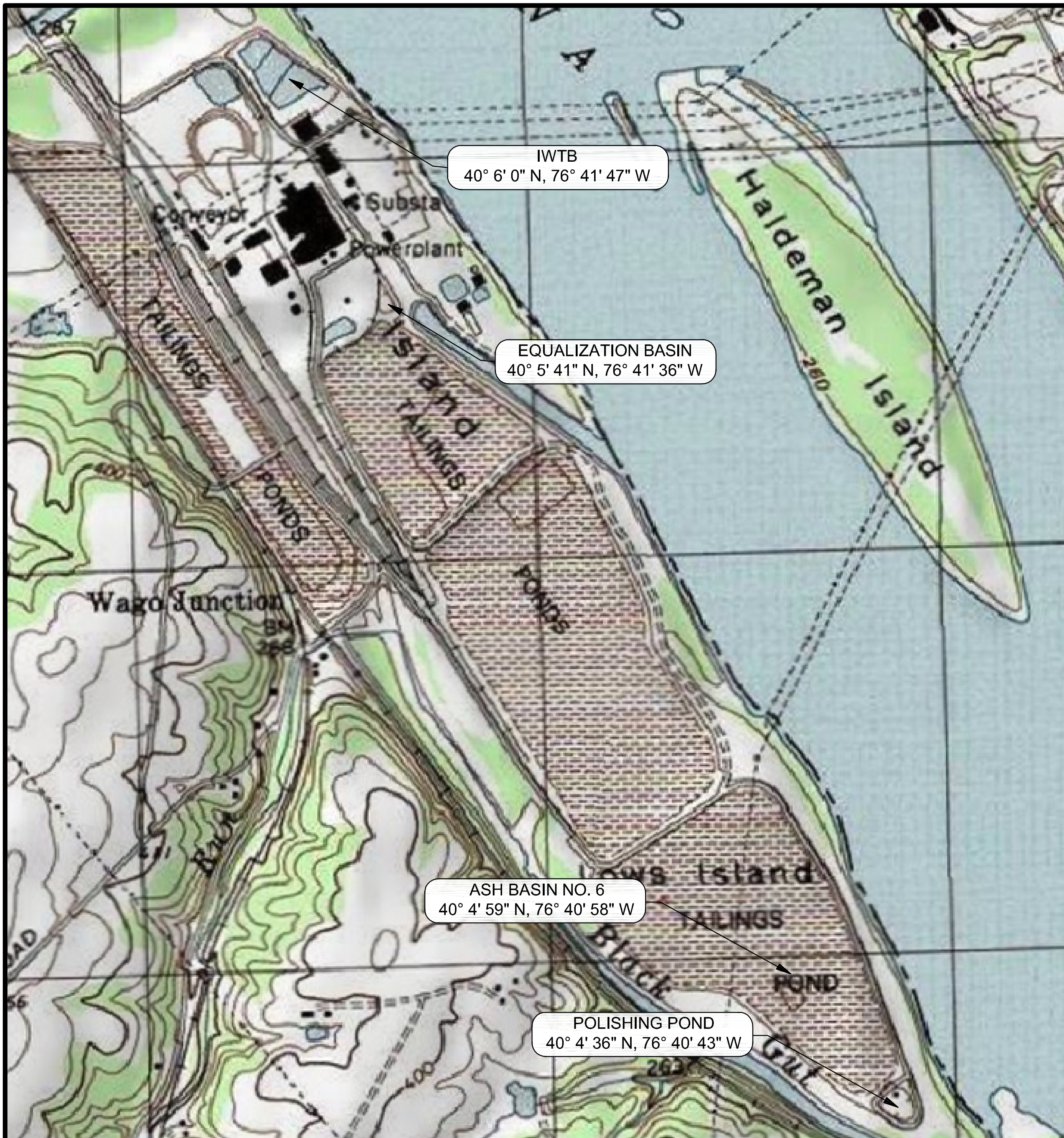
I acknowledge that the management units referenced herein, Ash Basin No. 6 has been assessed to be in **FAIR** condition.

James P. Guarente

James P. Guarente, P.E.
Senior Project Manager

FIGURES

© 2011 – GZA GeoEnvironmental, Inc. GZA-J:\170,000-179,999\170142\170142-30 Round 10\PPL Brunner Island\Drawings\170142-30_Figs 1 & 2.dwg [SiteLocus] August 12, 2011 – 11:34am charles.nourse



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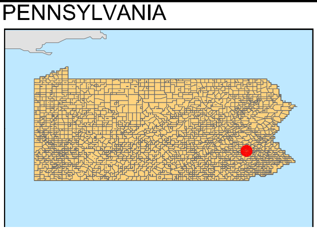


APPROXIMATE SITE LOCATION

SOURCE:

This map contains the ESRI ArcGIS Online World Topographic Map or Aerial Imagery service, Published February 2011 by ESRI ARCIMS Services. The service was compiled to uniform cartography using a variety of best available sources from several data providers.

0 600 1200 2400

SCALE IN FEET

N W E S

PPL BRUNNER ISLAND
WAGO ROAD
YORK HAVEN, PA 17370

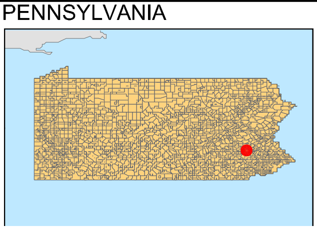
PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
THE U.S. ENVIRONMENTAL PROTECTION AGENCY RESOURCE AND RECOVERY

LOCUS MAP
COAL COMBUSTION
SURFACE IMPOUNDMENTS

PROJ MGR: UPG	REVIEWED BY: UPG	CHECKED BY: CKD	FIG OR DWG
DESIGNED BY: CBN	DRAWN BY: JRC	SCALE: 1":1200'	1
DATE: 08-05-2011	PROJECT NO. 170142.30	REVISION NO.	SHEET NO.

PENNSYLVANIA



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SOURCE:

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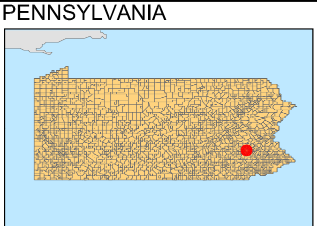
ORTHO-PHOTO LOCUS MAP
COAL COMBUSTION
SURFACE IMPOUNDMENTS

PROJ MGR: UPG	REVIEWED BY: UPG	CHECKED BY: CKD	FIG OR DWG
DESIGNED BY: CBN	DRAWN BY: JRC	SCALE: 1":1200'	2
DATE: 08-05-2011	PROJECT NO. 170142.30	REVISION NO.	SHEET NO.

PENNSYLVANIA



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SOURCE:

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0 2500 5000 10000

SCALE IN FEET

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DOWNSTREAM AREA MAP
COAL COMBUSTION
SURFACE IMPOUNDMENTS

PROJ MGR: JPG	REVIEWED BY: JPG	CHECKED BY: CKD	FIG OR DWG
DESIGNED BY: CBN	DRAWN BY: CBN	SCALE: 1":5000'	3
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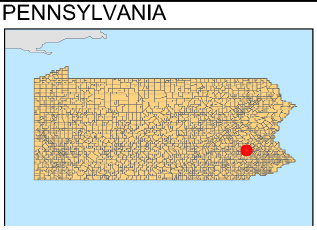
PENNSYLVANIA



APPROXIMATE SITE LOCATION

SOURCE:

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0 600 1200 2400

SCALE IN FEET

N W E S

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WAGO ROAD
YORK HAVEN, PA 17370

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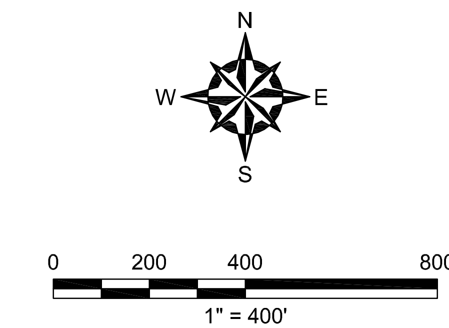
ASH BASIN NO. 6 (WITH ASSOCIATED POLISHING POND) DRAINAGE AREA
COAL COMBUSTION SURFACE IMPOUNDMENTS

PROJ MGR: JPG	REVIEWED BY: JPG	CHECKED BY: CKD	FIG OR DWG
DESIGNED BY: CBN	DRAWN BY: CBN	SCALE: 1":1200'	4
DATE: 08-05-2011	PROJECT NO. 170142.30	REVISION NO.	SHEET NO.



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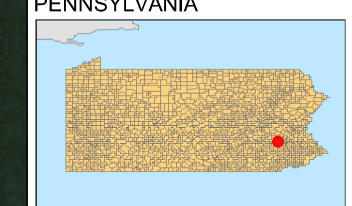

APPROXIMATE SITE LOCATION

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PPL BRUNNER ISLAND
WAGO ROAD
YORK HAVEN, PA 17370

SITE PLAN/FIELD SKETCH
ASH BASIN NO. 6 & POLISHING POND
COAL COMBUSTION SURFACE IMPOUNDMENTS

PREPARED BY:		PREPARED FOR:	
GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		THE U.S. ENVIRONMENTAL PROTECTION AGENCY RESOURCE AND RECOVERY	
PROJ MGR: JPG	REVIEWED BY: JPG	CHECKED BY: PHB	FIGURE
DESIGNED BY: CBN	DRAWN BY: CBN	SCALE: 1" = 400'	5
DATE: 08-05-2011	PROJECT NO. 170142.30	REVISION NO.	SHEET NO.

LEGEND

1 GZA PHOTO LOCATION/DIRECTION

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0 150 300 600

1" = 300'

PENNSYLVANIA

APPROXIMATE SITE LOCATION

SOURCE:

This map contains the ESRI ArcGIS Online World Topographic Map or Aerial Imagery service, Published February 2011 by ESRI ARCIMS Services. The service was compiled to uniform cartography using a variety of best available sources from several data providers.

PPL BRUNNER ISLAND
WAGO ROAD
YORK HAVEN, PA 17370

PHOTO LOCATION PLAN
BASIN 6
COAL COMBUSTION SURFACE IMPOUNDMENTS

PREPARED BY:
GZA GeoEnvironmental, Inc.
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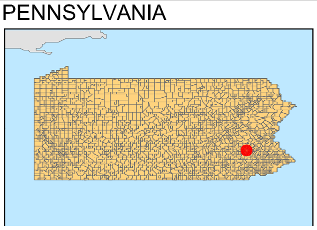
PROJ MGR: JPG	REVIEWED BY: JPG	CHECKED BY: PHB	FIGURE
DESIGNED BY: CBN	DRAWN BY: CBN/OCO	SCALE: 1" = 300'	6A
DATE: 08-05-2011	PROJECT NO. 170142.30	REVISION NO.	SHEET NO.

PENNSYLVANIA



APPROXIMATE SITE LOCATION

SOURCE:

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0 200 400 800

1" = 400'

N W E S

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WAGO ROAD
YORK HAVEN, PA 17370

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
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THE U.S. ENVIRONMENTAL PROTECTION AGENCY RESOURCE AND RECOVERY

PHOTO LOCATION PLAN
BOTTOM ASH TREATMENT SYSTEM
COAL COMBUSTION SURFACE IMPOUNDMENTS

PROJ MGR: JPG	REVIEWED BY: JPG	CHECKED BY: PHB	FIGURE
DESIGNED BY: CBN	DRAWN BY: CBN	SCALE: 1" = 100'	6B
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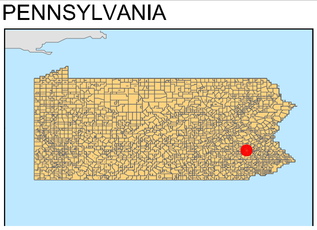
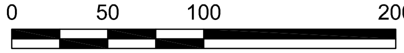
PENNSYLVANIA

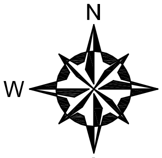


APPROXIMATE SITE LOCATION

SOURCE:

This map contains the ESRI ArcGIS Online World Topographic Map or Aerial Imagery service, Published February 2011 by ESRI ARCIMS Services. The service was compiled to uniform cartography using a variety of best available sources from several data providers.





PPL BRUNNER ISLAND
WAGO ROAD
YORK HAVEN, PA 17370

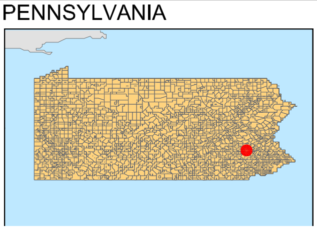
PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
THE U.S. ENVIRONMENTAL PROTECTION AGENCY RESOURCE AND RECOVERY

PHOTO LOCATION PLAN
BASIN 6 POLISHING POND
COAL COMBUSTION SURFACE IMPOUNDMENTS

PROJ MGR: JPG	REVIEWED BY: JPG	CHECKED BY: PHB	FIGURE
DESIGNED BY: CBN	DRAWN BY: CBN	SCALE: 1" = 100'	6C
DATE: 08-05-2011	PROJECT NO. 170142.30	REVISION NO.	SHEET NO.

PENNSYLVANIA



APPROXIMATE SITE LOCATION

SOURCE:

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0 50 100 200

1" = 100'

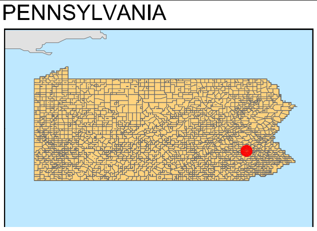
N W E S

PPL BRUNNER ISLAND WAGO ROAD YORK HAVEN, PA 17370	PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com	PREPARED FOR: THE U.S. ENVIRONMENTAL PROTECTION AGENCY RESOURCE AND RECOVERY	

PHOTO LOCATION PLAN
EQUALIZATION BASIN
COAL COMBUSTION SURFACE IMPOUNDMENTS

PROJ MGR: JPG	REVIEWED BY: JPG	CHECKED BY: PHB	FIGURE
DESIGNED BY: CBN	DRAWN BY: CBN/OCO	SCALE: 1"=100'	6D
DATE: 08-05-2011	PROJECT NO. 170142.30	REVISION NO.	SHEET NO.

PENNSYLVANIA



APPROXIMATE SITE LOCATION

SOURCE:

This map contains the ESRI ArcGIS Online World Topographic Map or Aerial Imagery service, Published February 2011 by ESRI ARCIMS Services. The service was compiled to uniform cartography using a variety of best available sources from several data providers.

0 75 150 300

1"=150'

N W E S

PPL BRUNNER ISLAND
WAGO ROAD
YORK HAVEN, PA 17370

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
THE U.S. ENVIRONMENTAL PROTECTION AGENCY RESOURCE AND RECOVERY

PHOTO LOCATION PLAN
INCIDENTAL WASTE TREATMENT BASIN (IWTB)
COAL COMBUSTION SURFACE IMPOUNDMENTS

PROJ MGR: JPG	REVIEWED BY: JPG	CHECKED BY: PHB	FIGURE
DESIGNED BY: CBN	DRAWN BY: OCO	SCALE: 1" = 150'	6E
DATE: 08-05-2011	PROJECT NO. 170142.30	REVISION NO.	SHEET NO.

APPENDIX A

LIMITATIONS

DAM ENGINEERING & VISUAL INSPECTION LIMITATIONS

1. The observations described in this report were made under the conditions stated herein. The conclusions presented in the report were based solely on the services described therein, and not on scientific tasks or procedures beyond the scope of described services.

2. In preparing this report, GZA GeoEnvironmental, Inc. (GZA) has relied on certain information provided by PPL Generation, LLC., and Federal, state, and local officials and other parties referenced therein. GZA has also relied on other parties which were available to GZA at the time of the inspection. Although there may have been some degree of overlap in the information provided by these various sources, GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this work.

3. In reviewing this Report, it should be realized that the reported condition of the dam is based on observations of field conditions during the course of this study along with data made available to GZA. The observations of conditions at the dam reflect only the situation present at the specific moment in time the observations were made, under the specific conditions present. It may be necessary to reevaluate the recommendations of this report when subsequent phases of evaluation or repair and improvement provide more data.

4. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions may be detected.

5. Water level readings have been reviewed and interpretations have been made in the text of this report. Fluctuations in the level of the groundwater and surface water may occur due to variations in rainfall, temperature, and other factors different than at the time measurements were made.

6. GZA's comments on the hydrology, hydraulics, and embankment stability for the dam are based on a limited review of available design documentation provided by PPL Generation, LLC.

7. This report has been prepared for the exclusive use of the US EPA for specific application to the existing dam facilities, in accordance with generally accepted dam engineering practices. No other warranty, express or implied, is made.

8. This dam inspection report has been prepared for this project by GZA. This report is for the owner's broad evaluation and management purposes only and is not sufficient, in and of itself, to prepare construction documents or an accurate bid.

APPENDIX B

DEFINITIONS

COMMON DAM SAFETY DEFINITIONS

For a comprehensive list of dam engineering terminology and definitions refer to references published by the U.S. Army Corps of Engineers, the Federal Energy Regulatory Commission, the Department of the Interior Bureau of Reclamation, or the Federal Emergency Management Agency.

Orientation

Upstream – Shall mean the side of the dam that borders the impoundment.

Downstream – Shall mean the high side of the dam, the side opposite the upstream side.

Right – Shall mean the area to the right when looking in the downstream direction.

Left – Shall mean the area to the left when looking in the downstream direction.

Dam Components

Dam – Shall mean any artificial barrier, including appurtenant works, which impounds or diverts water.

Embankment – Shall mean the fill material, usually earth or rock, placed with sloping sides, such that it forms a permanent barrier that impounds water.

Crest – Shall mean the top of the dam, usually provides a road or path across the dam.

Abutment – Shall mean that part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section, to take the thrust of an arch dam where there is no suitable natural abutment.

Appurtenant Works – Shall mean structures, either in dams or separate therefrom, including but not be limited to, spillways; reservoirs and their rims; low-level outlet works; and water conduits including tunnels, pipelines, or penstocks, either through the dams or their abutments.

Spillway – Shall mean a structure over or through which water flows are discharged. If the flow is controlled by gates or boards, it is a controlled spillway; if the fixed elevation of the spillway crest controls the level of the impoundment, it is an uncontrolled spillway.

General

EAP – Emergency Action Plan – Shall mean a predetermined (and properly documented) plan of action to be taken to reduce the potential for property damage and/or loss of life in an area affected by an impending dam failure.

O&M Manual – Operations and Maintenance Manual; Document identifying routine maintenance and operational procedures under normal and storm conditions.

Normal Pool – Shall mean the elevation of the impoundment during normal operating conditions.

Acre-foot – Shall mean a unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet. One million U.S. gallons = 3.068 acre feet.

Height of Dam (Structural Height) – Shall mean the vertical distance from the lowest portion of the natural ground, including any stream channel, along the downstream toe of the dam to the lowest point on the crest of the dam.

Hydraulic Height – means the height to which water rises behind a dam and the difference between the lowest point in the original streambed at the axis of the dam and the maximum controllable water surface.

Maximum Water Storage Elevation – means the maximum elevation of water surface which can be contained by the dam without overtopping the embankment section.

Spillway Design Flood (SDF) – Shall mean the flood used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.

Maximum Storage Capacity – The volume of water contained in the impoundment at maximum water storage elevation.

Normal Storage Capacity – The volume of water contained in the impoundment at normal water storage elevation.

Condition Rating

SATISFACTORY - No existing potential management unit safety deficiencies are recognized. Acceptable performance is expected under all applicable loading conditions (static, hydrologic, seismic) in accordance with the applicable criteria. Minor maintenance items may be required.

FAIR – Acceptable performance is expected under all required loading conditions (Static, hydrologic, seismic) in accordance with the applicable safety regulatory criteria. Minor deficiencies may exist that require remedial action and/or secondary studies or investigations.

POOR – A management unit safety deficiency is recognized for any required loading condition (static, hydrologic, seismic) in accordance with the applicable dam safety regulatory criteria. Remedial action is necessary. POOR also applies when further critical studies or investigations are needed to identify any potential dam safety deficiencies.

UNSATISFACTORY – Considered unsafe. A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution. Reservoir restrictions may be necessary.

Hazard Potential

(In the event the impoundment should fail, the following would occur):

LESS THAN LOW HAZARD POTENTIAL: Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

LOW HAZARD POTENTIAL: Dams assigned the low hazard potential classifications are those dams where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

SIGNIFICANT HAZARD POTENTIAL: Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

HIGH HAZARD POTENTIAL: Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

APPENDIX C

INSPECTION CHECKLISTS

Site Name:	PPL Brunner Island	Date:	May 18, 2011
Unit Name:	Ash Basin No. 6 Impoundment	Operator's Name:	PPL Brunner Island, LLC
Unit I.D.:		Hazard Potential Classification:	High Significant Low ✓
Inspector's Name:	James P. Guarente, P.E. and C. Brad Nourse (GZA GeoEnvironmental, Inc.)		

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	Daily		18. Sloughing or bulging on slopes?	✓	
2. Pool elevation (operator records)?	287.3' +/-		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?	See note		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	N/A		Is water entering inlet, but not exiting outlet?		✓
5. Lowest dam crest elevation (operator records)?	N/A		Is water exiting outlet, but not entering inlet?		✓
6. If instrumentation is present, are readings recorded (operator records)?	✓		Is water exiting outlet flowing clear?	✓	
7. Is the embankment currently under construction?		✓	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?	✓		From underdrain?		✓
9. Trees growing on embankment? (If so, indicate largest diameter below)	✓		At isolated points on embankment slopes?	✓	
10. Cracks or scarps on crest?		✓	At natural hillside in the embankment area?		✓
11. Is there significant settlement along the crest?		✓	Over widespread areas?		✓
12. Are decant trashracks clear and in place?	✓		From downstream foundation area?		✓
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓	"Boils" beneath stream or ponded water?		✓
14. Clogged spillways, groin or diversion ditches?		✓	Around the outside of the decant pipe?		✓
15. Are spillway or ditch linings deteriorated?		✓	22. Surface movements in valley bottom or on hillside?		✓
16. Are outlets of decant or underdrains blocked?		✓	23. Water against downstream toe?		✓
17. Cracks or scarps on slopes?		✓	24. Were Photos taken during the dam inspection?	✓	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue #	Comments

1. Daily walk over by plant personnel; quarterly inspection by civil engineer from operator's home office. Yearly inspection with report by independent outside consultant.

3. Invert of pipe leading to polishing pond is at elevation 271.0'. Skimmer gates and stoplogs at intake structure serve to maintain pool level within basin generally between el. 286.5 to 287.5' +/-.

6. Four embankment piezometers generally read during annual inspection; staff gage at inlet and electric water level transducers are read/monitored regularly.

9.Dense phragmites and related grass/shrubbery present on slope around entire inside of free standing water limits. Presence prevented close inspection of these areas.

18. Occasional minor sloughing at various locations on downstream slopes of embankment. Site monitors conditions and repairs/regrades when necessary.

21. Saturated conditions and shallow standing water observed along a portion of the downstream toe. May be a result of past month's heavy rainfall and high river conditions. No flow/active seepage observed. All standing water clear.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # **PA 0008281** INSPECTOR **James P. Guarente, P.E.**
C. Brad Nourse

Date **May 18, 2011**

Impoundment Name **PPL Brunner Island - Ash Basin No. 6 Impoundment**
Impoundment Company **PPL Brunner Island, LLC**
EPA Region **Region III**
State Agency (Field Office) Addresss **DEP South Central Regional Office**
909 Elmerton Avenue, Harrisburg, PA 17710
Name of Impoundment **PPL Brunner Island - Ash Basin No. 6**
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New ________ Update **X**

	Yes	No
Is impoundment currently under construction?		X
Is water or ccw currently being pumped into the impoundment?	X	

IMPOUNDMENT FUNCTION: **Receives inflow from bottom ash slurry treatment system and residual waste water from the equalization pond.**

Nearest Downstream Town : Name **Saginaw, PA**
Distance from the impoundment **1.0 miles measured in straight line on Google Earth.**
Impoundment
Location: Longitude **76** Degrees **40** Minutes **58** Seconds
Latitude **40** Degrees **4** Minutes **59** Seconds
State **PA** County **York**

Does a state agency regulate this impoundment? YES **X** NO ______

If So Which State Agency? **PADEP Office of Dam Safety and PADEP Bureau of Land Recycling and Waste Management**

HAZARD POTENTIAL (In the event the impoundment should fail, the following would occur):

______ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

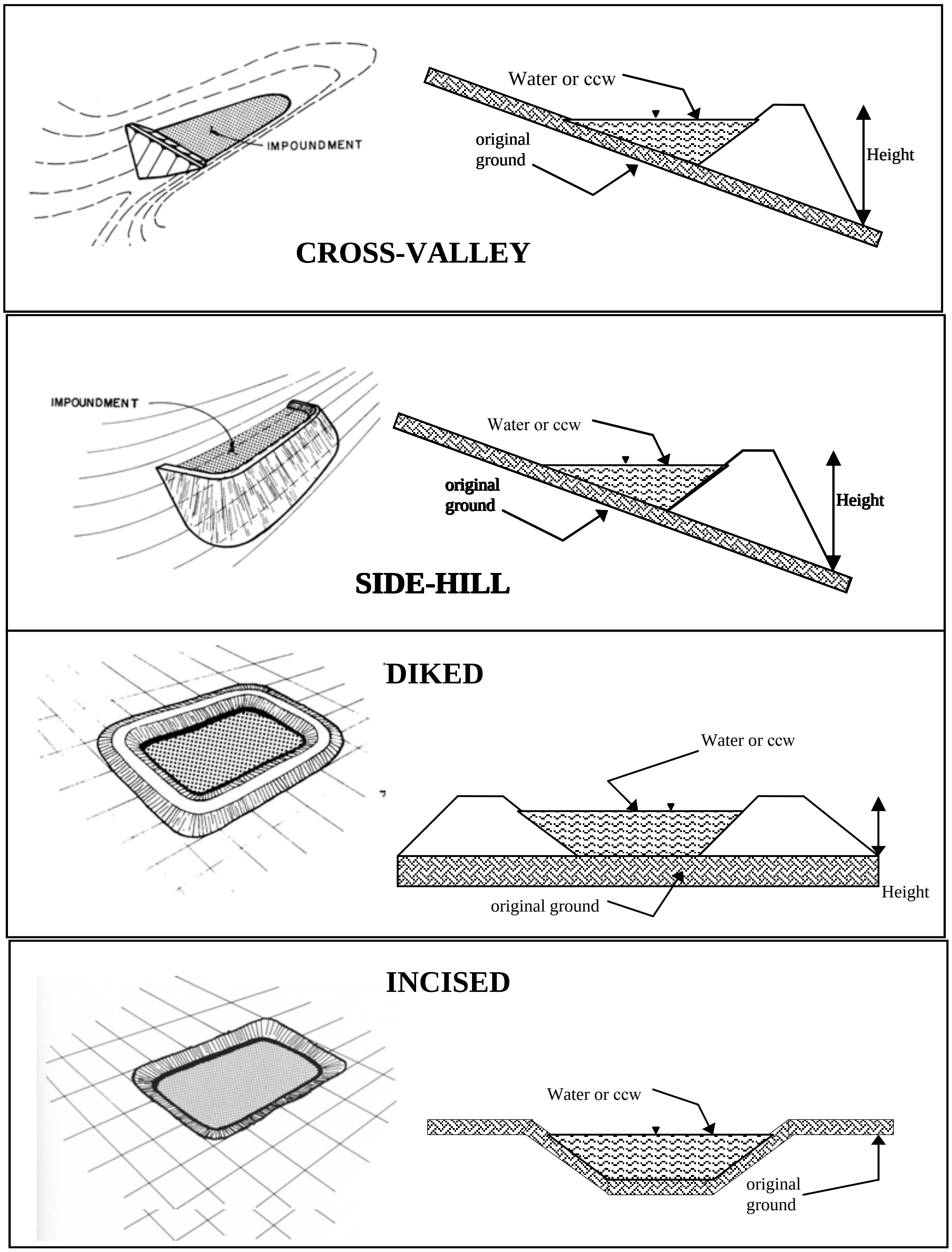
__X___ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

According to the 2010 Annual Inspection Report by HDR Engineering, Inc., the Ash Basin Dam is classified as a Size B, Hazard Classification 2 by the Pennsylvania Department of Environmental Protection (PADEP) corresponding to a medium sized, significant hazard potential dam. In our opinion, failure of the impoundment is not likely to result in loss of human life. Additionally, it is noted that the majority of the 70 acre-sized impoundment has been filled with ash waste covered with soil, there is no contributing watershed and only approximately 11 acres has free standing water. Nevertheless given the height of the embankment, and the amount of water and ash stored therein, a sudden uncontrolled release could cause economic loss and environmental damage to the adjacent Susquehanna River or adjacent rural land area.

CONFIGURATION:



_____ Cross-Valley
_____ Side-Hill
_____ Diked
_____ Incised (form completion optional)
__X__ Combination Incised/Diked

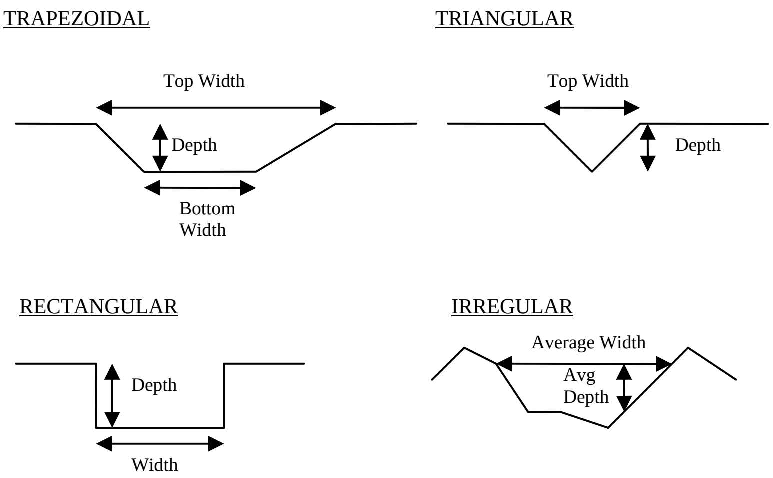
Embankment Height __up to 39__ feet
Pool Area __approximately 11__ acres
Current Freeboard __approximately 3__ feet

Embankment Material __Original design drawings specified inorganic fill from basin excavation be used to construct embankment slopes.__
Liner __Original design drawings specified a 10-foot thick clay liner on the upstream slope.__
Liner Permeability __Essentially impermeable.__

TYPE OF OUTLET (Mark all that apply)

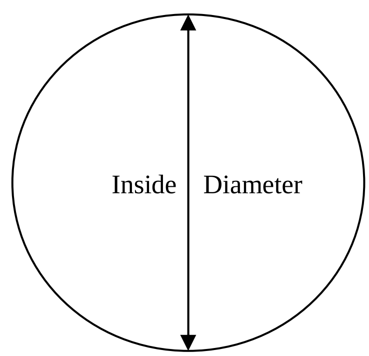
_____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
_____ Rectangular
_____ Irregular

_____ depth
_____ bottom (or average) width
_____ top width



__X__ **Outlet**

__48"__ inside diameter



Material
_____ corrugated metal
_____ welded steel
__X__ concrete
_____ plastic (hdpe, pvc, etc.)
_____ other (specify) _____________________

Is water flowing through the outlet? YES __X__ NO _______

_____ **No Outlet**

_____ **Other Type of Outlet** (specify) _______________________________

The Impoundment was Designed By Original (circa 1978) design by Pennsylvania Power and Light Company; modifications by Kleinschmidt Energy and Water Resource Consultants.

Has there ever been a failure at this site? YES ___________ NO ___X________

If So When? ______________________________

If So Please Describe : ____

Has there ever been significant seepages at this site? YES ________ NO __x____

If So When? ____________________________

IF So Please Describe: ____

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	PPL Brunner Island	Date:	May 18, 2011
Unit Name:	Ash Basin No. 6 (Polishing Pond)	Operator's Name:	PPL Brunner Island, LLC
Unit I.D.:		Hazard Potential Classification:	High / Significant / Low ✓
Inspector's Name:	James P. Guarente, P.E. and C. Brad Nourse (GZA GeoEnvironmental, Inc.)		

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	Daily		18. Sloughing or bulging on slopes?	✓	
2. Pool elevation (operator records)?	268'		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?	See note		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	N/A		Is water entering inlet, but not exiting outlet?		✓
5. Lowest dam crest elevation (operator records)?	N/A		Is water exiting outlet, but not entering inlet?		✓
6. If instrumentation is present, are readings recorded (operator records)?		✓	Is water exiting outlet flowing clear?	✓	
7. Is the embankment currently under construction?		✓	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?	✓		From underdrain?		✓
9. Trees growing on embankment? (If so, indicate largest diameter below)		✓	At isolated points on embankment slopes?	✓	
10. Cracks or scarps on crest?		✓	At natural hillside in the embankment area?		✓
11. Is there significant settlement along the crest?		✓	Over widespread areas?		✓
12. Are decant trashracks clear and in place?	✓		From downstream foundation area?		✓
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓	"Boils" beneath stream or ponded water?		✓
14. Clogged spillways, groin or diversion ditches?		✓	Around the outside of the decant pipe?		✓
15. Are spillway or ditch linings deteriorated?		✓	22. Surface movements in valley bottom or on hillside?		✓
16. Are outlets of decant or underdrains blocked?		✓	23. Water against downstream toe?		✓
17. Cracks or scarps on slopes?		✓	24. Were Photos taken during the dam inspection?	✓	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue # Comments

1.Daily walk over by plant personnel; quarterly inspection by civil engineer from operator's home office. Yearly inspection with report by independent outside consultant.

3. Invert of 48-inch diameter outlet pipe leading to Susquehanna River outfall is at elevation 253'. Outlet structure consists of two 60-inch diameter reinforced riser pipes with skimmer gates which serve to maintain pool level generally at elevation 268.0'.

9. Moderate to dense grass growth present on slopes around entire inside of pond. Presence prevented close inspection of these areas.

18. Occasional minor sloughing at various locations on downstream slopes of embankment. Site monitors conditions and repairs/regrades when necessary.

21. Saturated conditions and shallow standing water observed along a majority of the downstream toe. May be a result of past month's heavy rainfall and high river conditions. No flow/active seepage observed. All standing water clear.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # PA 0008281 INSPECTOR C. Brad Nourse
James P. Guarente, P.E.

Date May 18, 2011

Impoundment Name PPL Brunner Island (Ash Basin No. 6) Polishing Pond
Impoundment Company PPL Brunner Island LLC
EPA Region Region III
State Agency (Field Office) Addresss DEP South Central Regional Office
909 Elmerton Ave.,Harrisburg,PA 17710
Name of Impoundment PPL Brunner Island (Ash Basin No. 6) Polishing Pond
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New ________ Update X

	Yes	No
Is impoundment currently under construction?		X
Is water or ccw currently being pumped into the impoundment?	X	

(water enters polishing pond via gravity flow from Ash Basin No. 6 intake structure outlet pipe)

IMPOUNDMENT FUNCTION: Receives decant inflow from Ash Basin No. 6 Impoundment.

Nearest Downstream Town : Name Saginaw, Pa
Distance from the impoundment 1.0 miles measured in a straight line on Google Earth.
Impoundment
Location: Longitude 76 Degrees 40 Minutes 43 Seconds
Latitude 40 Degrees 4 Minutes 36 Seconds
State PA County York

Does a state agency regulate this impoundment? YES X NO ______

If So Which State Agency? PADEP Office of Dam Safety and PADEP Bureau of Land Recycling and Waste Management

<u>HAZARD POTENTIAL</u> (In the event the impoundment should fail, the following would occur):

______ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

__X___ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

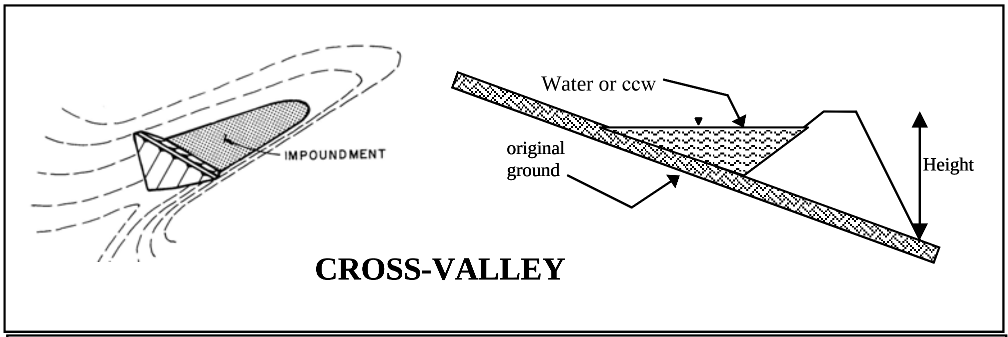
______ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

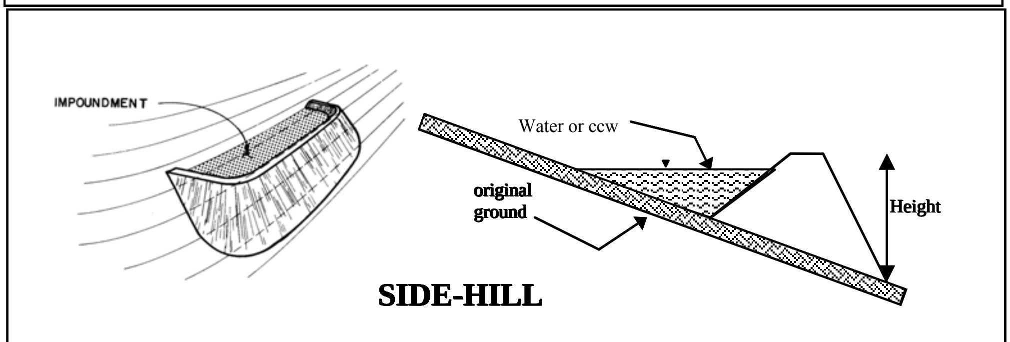
______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

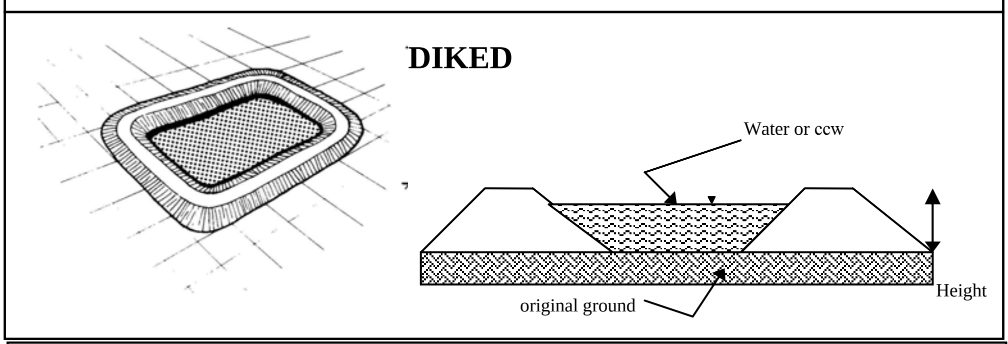
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

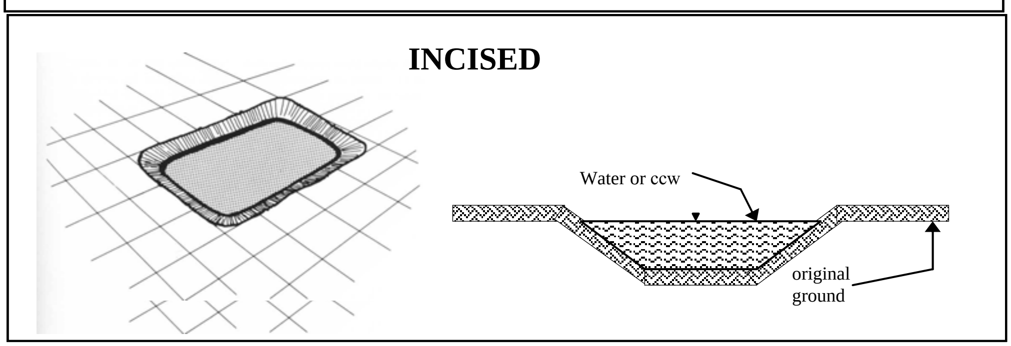
In our opinion, failure of the polishing pond embankment is not likely to results in loss of human life. Additionally, considering the size of the pond is less than one acre, environmental damage to the Susquehanna River or adjacent land area resulting from a failure is estimated to be low.

CONFIGURATION:









______ Cross-Valley
______ Side-Hill
______ Diked
______ Incised (form completion optional)
__X__ Combination Incised/Diked

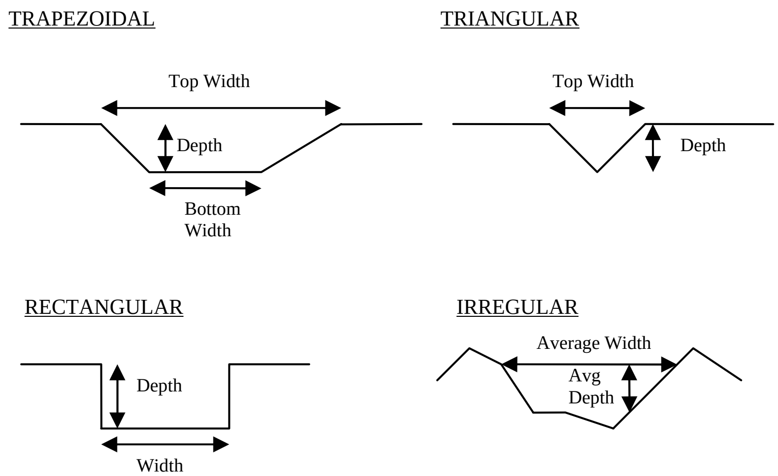
Embankment Height **up to 39** feet
Pool Area **less than one** acres
Current Freeboard **approx. 22** feet

Embankment Material **Original design drawings specified inorganic fill from excavation be used to construct embankment slopes.**
Liner **Original design drawing specified a 10-foot thick clay liner on the upstream slope.**
Liner Permeability **Essentially impermeable.**

TYPE OF OUTLET (Mark all that apply)

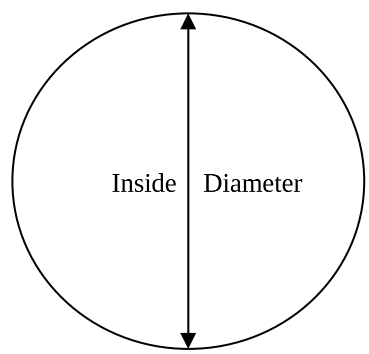
_____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
_____ Rectangular
_____ Irregular

_____ depth
_____ bottom (or average) width
_____ top width



__X__ **Outlet**

_48"_ inside diameter



Material
_____ corrugated metal
_____ welded steel
__X__ concrete
_____ plastic (hdpe, pvc, etc.)
_____ other (specify) ______________________

Is water flowing through the outlet? YES _X____ NO _______

_____ **No Outlet**

_____ **Other Type of Outlet** (specify) ____________________________________

The Impoundment was Designed By **Originally designed by Pennsylvania Power and Light Company; modifications by Kleinschmidt Energy and Water Resource Consultants.**

Has there ever been a failure at this site? YES __________ NO ____X______

If So When? ____________________________

If So Please Describe : ____

Has there ever been significant seepages at this site? YES ________ NO __X____

If So When? ____________________________

IF So Please Describe: ____

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ________NO __X_____

If so, which method (e.g., piezometers, gw pumping,...)? ____________________

If so Please Describe : ____________________

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ________NO ___X_____

If so, which method (e.g., piezometers, gw pumping,...)? ____________________

If so Please Describe : ____

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	PPL Brunner Island	Date:	May 18, 2011
Unit Name:	Incidental Waste Treatment Basin	Operator's Name:	PPL Brunner Island, LLC
Unit I.D.:		Hazard Potential Classification:	High Significant Low ✓
Inspector's Name:	James P. Guarente, P.E. and C. Brad Nourse (GZA GeoEnvironmental, Inc.)		

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	See note		18. Sloughing or bulging on slopes?		✓
2. Pool elevation (operator records)?	267' +/-		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?	265.3' +/-		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	N/A		Is water entering inlet, but not exiting outlet?		✓
5. Lowest dam crest elevation (operator records)?	272.5' +/-		Is water exiting outlet, but not entering inlet?		✓
6. If instrumentation is present, are readings recorded (operator records)?	See	note	Is water exiting outlet flowing clear?	✓	
7. Is the embankment currently under construction?		✓	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?	✓		From underdrain?		✓
9. Trees growing on embankment? (If so, indicate largest diameter below)	✓		At isolated points on embankment slopes?		✓
10. Cracks or scarps on crest?	✓		At natural hillside in the embankment area?		✓
11. Is there significant settlement along the crest?		✓	Over widespread areas?		✓
12. Are decant trashracks clear and in place?		✓	From downstream foundation area?		✓
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓	"Boils" beneath stream or ponded water?		✓
14. Clogged spillways, groin or diversion ditches?		✓	Around the outside of the decant pipe?		✓
15. Are spillway or ditch linings deteriorated?		✓	22. Surface movements in valley bottom or on hillside?		✓
16. Are outlets of decant or underdrains blocked?		✓	23. Water against downstream toe?		✓
17. Cracks or scarps on slopes?		✓	24. Were Photos taken during the dam inspection?	✓	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue # Comments

1. Semi-annual inspection documented by plant personnel. Plant personnel also conduct a daily walk around inspection.

3.Skimmer gate generally controls water elevation within pool at approximately 267' +/-.

6. Series of observation wells installed outside diked area adjacent to impoundment (primarily north and east sides). Wells are periodically sampled for water quality; no formal documentation of water level is maintained.

9. High vegetation with moderately-sized shrubbery present on embankment slopes in need of maintenance. Large trees (up to 24" diameter) on outside slopes of adjacent north and east side outer dike which also serves as a Susquehanna River flood control dike.

19. Occasional localized erosion/washout from surface water runoff observed on crest and interior dike slopes.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # **PA 0008281**
INSPECTOR **C. Brad Nourse**
James P. Guarente, P.E.
Date **May 18, 2011**

Impoundment Name **PPL Brunner Island - Incidental Waste Treatment Basin**
Impoundment Company **PPL Brunner Island, LLC**
EPA Region **Region III**
State Agency (Field Office) Addresss **DEP South Central Regional Office**
909 Elmerton Ave.,Harrisburg,PA 17110
Name of Impoundment **PPL Brunner Island - Incidental Waste Treatment Basin**
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New ________ Update **X**

	Yes	No
Is impoundment currently under construction?		X
Is water or ccw currently being pumped into the impoundment?	X	

IMPOUNDMENT FUNCTION: Receives effluent from the onsite water treatment plant and surface water/stormwater runoff from the coal storage pile.

Nearest Downstream Town : Name **Manchester, PA**
Distance from the impoundment Approximately 1.0 miles measured in straight line on Google Earth.
Impoundment
Location: Longitude **76** Degrees **41** Minutes **47** Seconds
Latitude **40** Degrees **6** Minutes **0** Seconds
State **PA** County **York**

Does a state agency regulate this impoundment? YES **X** NO ______

If So Which State Agency? **Pennsylvania Department of Environmental Protection (DEP), Bureau of Land Recycling and Waste Management**

HAZARD POTENTIAL (In the event the impoundment should fail, the following would occur):

__X___ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

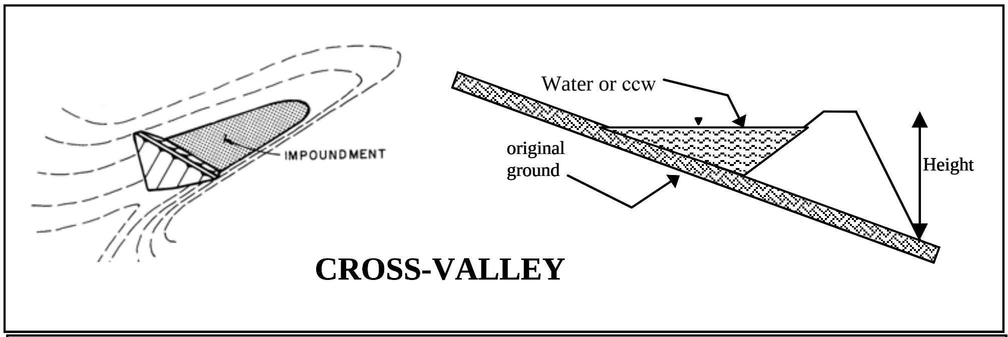
______ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

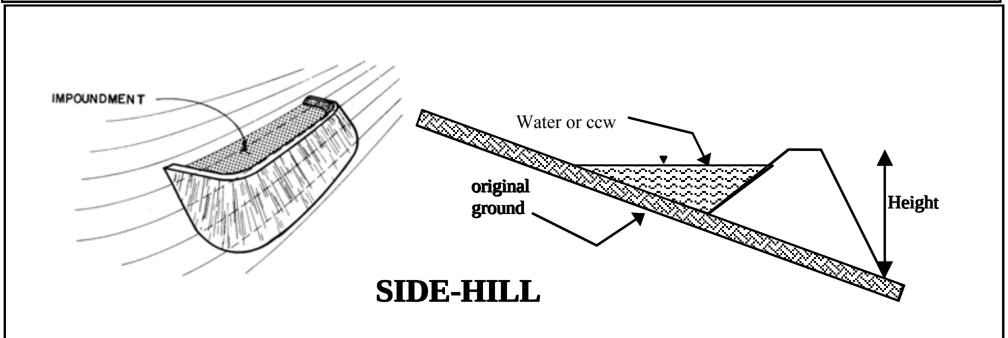
______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

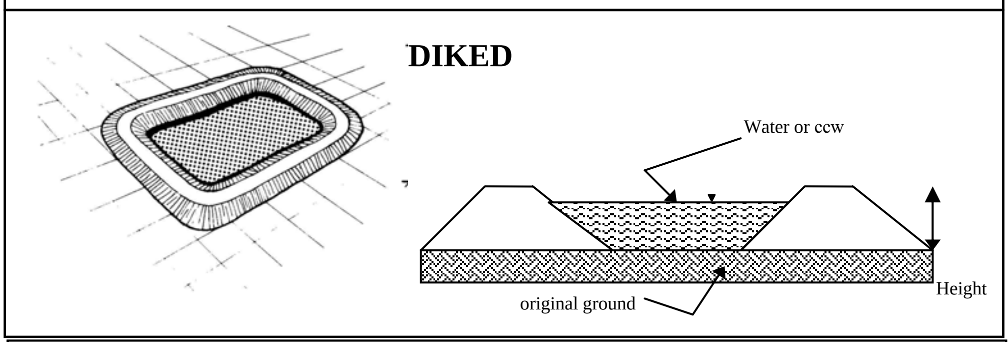
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

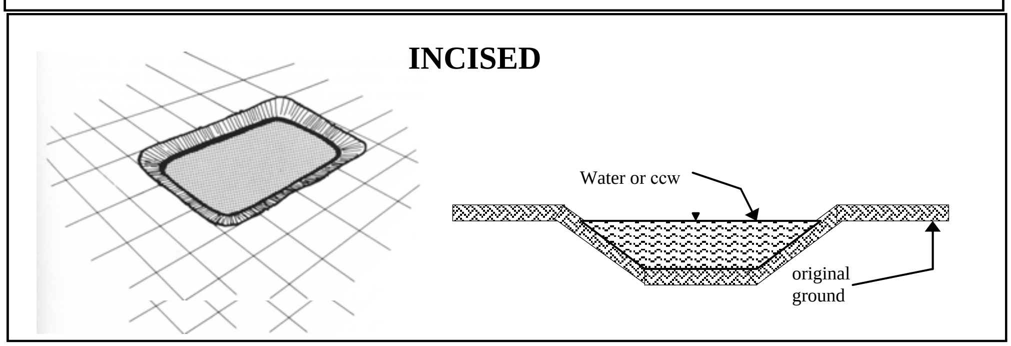
Although the impoundment is diked on all sides, the land outside the dikes immediately surrounding its south and west sides is generally at a higher elevation. Land beyond the dike along the north and east sides is generally only 3 to 5 feet lower than the highest water level which could be impounded. Review of original design drawings indicates a majority of the impoundment was incised below original grades when constructed. Failure is not likely to result in loss of human life and environmental damage, if any, would primarily be limited to owner's property.

CONFIGURATION:









______ Cross-Valley
______ Side-Hill
______ Diked
______ Incised (form completion optional)
__X__ Combination Incised/Diked **(mostly incised)**

Embankment Height **See Note 1** feet   Embankment Material **Review of design drawings indicate majority of impoundment was incised.**
Pool Area **approximately 7** acres   Liner **None indicated**
Current Freeboard **See Note 2** feet   Liner Permeability **N/A**

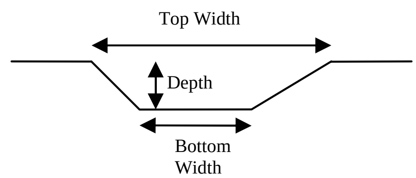
Note 1: Approximately 19' along north and east sides. 8.5' along south and west sides.
Note 2: Approximately 16' along north and east sides. 5.5' along south and west sides.

TYPE OF OUTLET (Mark all that apply)

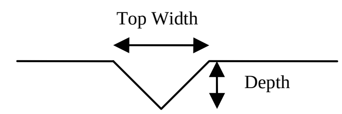
_____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
_____ Rectangular
_____ Irregular

_____ depth
_____ bottom (or average) width
_____ top width

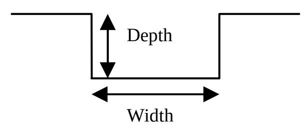
TRAPEZOIDAL



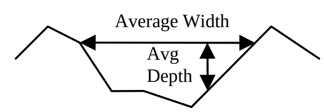
TRIANGULAR



RECTANGULAR

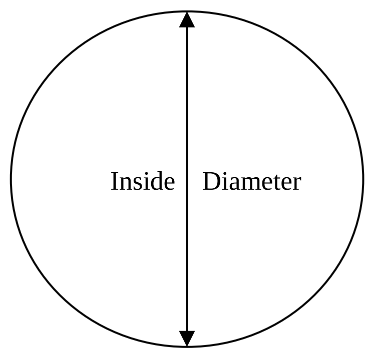


IRREGULAR



__X__ **Outlet**

__36"__ inside diameter



Material
__X__ corrugated metal
_____ welded steel
_____ concrete
_____ plastic (hdpe, pvc, etc.)
_____ other (specify) ______________________

Is water flowing through the outlet? YES __X__ NO _______

_____ **No Outlet**

_____ **Other Type of Outlet** (specify) ___________________________________

The Impoundment was Designed By **Original (circa 1972 as modified at various times) by Pennsylvania Power and Light Company In-House Design Engineers.**

Has there ever been a failure at this site? YES __________ NO ___X_______

If So When? ___________________________

If So Please Describe : ____

Has there ever been significant seepages at this site? YES ________ NO __X_____

If So When? ___________________________

IF So Please Describe: ____

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ________NO __X_____

If so, which method (e.g., piezometers, gw pumping,...)? ___________________

If so Please Describe : ____

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	PPL Brunner Island	Date:	May 18, 2011
Unit Name:	Equalization Pond	Operator's Name:	PPL Brunner Island, LLC
Unit I.D.:		Hazard Potential Classification:	High Significant Low ✓
Inspector's Name:	James P. Guarente, P.E. and C. Brad Nourse (GZA GeoEnvironmental, Inc.)		

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	See Note		18. Sloughing or bulging on slopes?		✓
2. Pool elevation (operator records)?	Varies		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?	268.3' +/-		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	N/A		Is water entering inlet, but not exiting outlet?		✓
5. Lowest dam crest elevation (operator records)?	282.0' +/-		Is water exiting outlet, but not entering inlet?		✓
6. If instrumentation is present, are readings recorded (operator records)?		✓	Is water exiting outlet flowing clear?		N/A
7. Is the embankment currently under construction?		✓	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?	✓		From underdrain?		✓
9. Trees growing on embankment? (If so, indicate largest diameter below)	✓		At isolated points on embankment slopes?		✓
10. Cracks or scarps on crest?		✓	At natural hillside in the embankment area?		✓
11. Is there significant settlement along the crest?		✓	Over widespread areas?		✓
12. Are decant trashracks clear and in place?	N/A		From downstream foundation area?		✓
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓	"Boils" beneath stream or ponded water?		✓
14. Clogged spillways, groin or diversion ditches?		✓	Around the outside of the decant pipe?		✓
15. Are spillway or ditch linings deteriorated?		✓	22. Surface movements in valley bottom or on hillside?		✓
16. Are outlets of decant or underdrains blocked?		✓	23. Water against downstream toe?		✓
17. Cracks or scarps on slopes?		✓	24. Were Photos taken during the dam inspection?	✓	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue # | Comments

1. Semi-annual inspection documented by plant personnel.

8. Knee-high vegetation with moderately-sized shrubbery present on east slope in need of maintenance.

20. Outlet from pond leads to adjacent sump pit and is then pumped to discharge channel outfall at north end of Ash Basin No. 6.

EPA FORM -XXXX

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW) Impoundment Inspection

Impoundment NPDES Permit # PA 0008281

INSPECTOR C. Brad Nourse
James P. Guarente, P.E.

Date May 18, 2011

Impoundment Name PPL Brunner Island - Equalization Pond
Impoundment Company PPL Brunner Island, LLC
EPA Region Region III
State Agency (Field Office) Addresss DEP South Central Regional Office
909 Elmerton Ave.,Harrisburg,PA 17110
Name of Impoundment PPL Brunner Island - Equalization Pond
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New ________ Update X

	Yes	No
Is impoundment currently under construction?		X
Is water or ccw currently being pumped into the impoundment?	X	

IMPOUNDMENT FUNCTION: Receives runoff and incidental plant waste flows.

Nearest Downstream Town : Name Manchester, PA
Distance from the impoundment Approximately 1.0 miles measured in straight line on Google Earth.
Impoundment
Location: Longitude 76 Degrees 41 Minutes 36 Seconds
Latitude 40 Degrees 5 Minutes 41 Seconds
State PA County York

Does a state agency regulate this impoundment? YES X NO ______

If So Which State Agency? Pennsylvania Department of Environmental Protection (DEP), Bureau of Water Quality

<u>HAZARD POTENTIAL</u> (In the event the impoundment should fail, the following would occur):

__X___ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

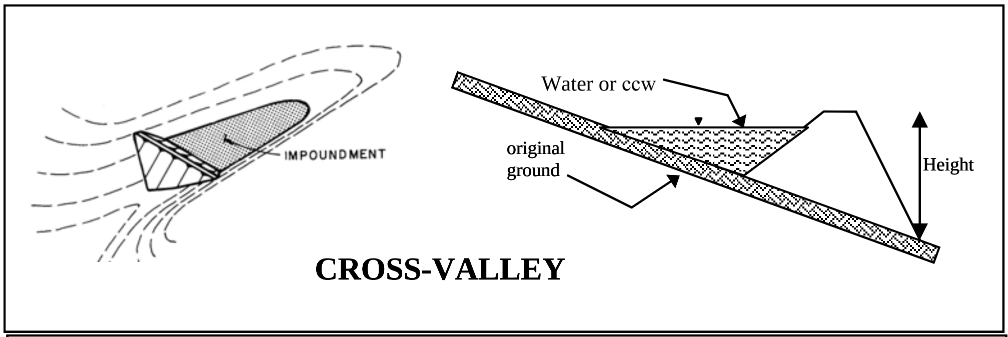
______ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

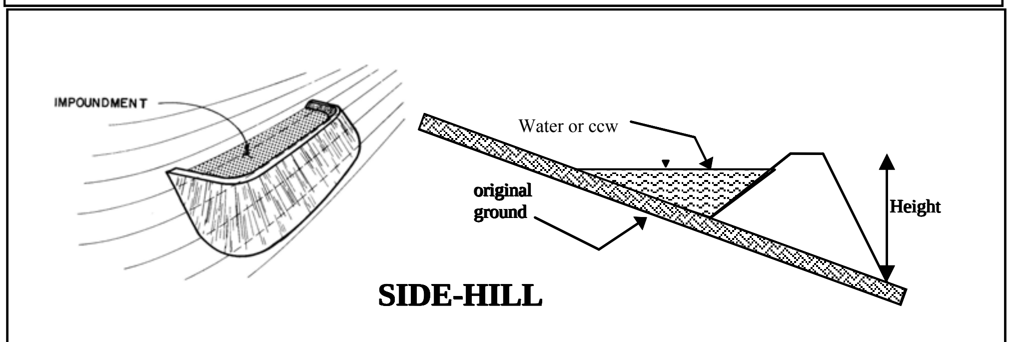
______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

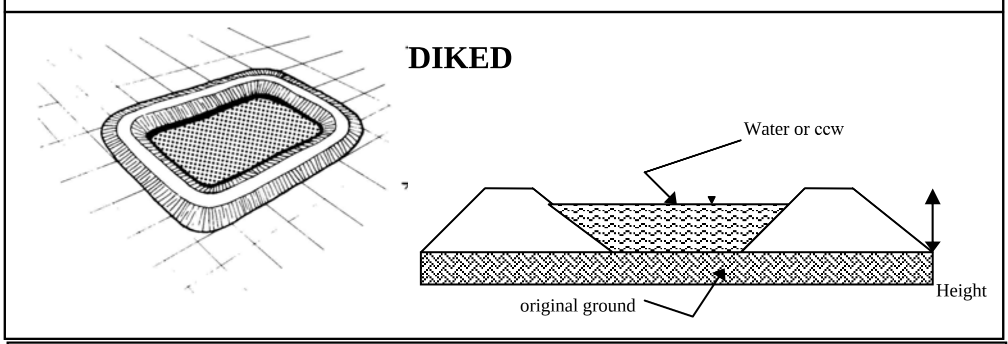
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

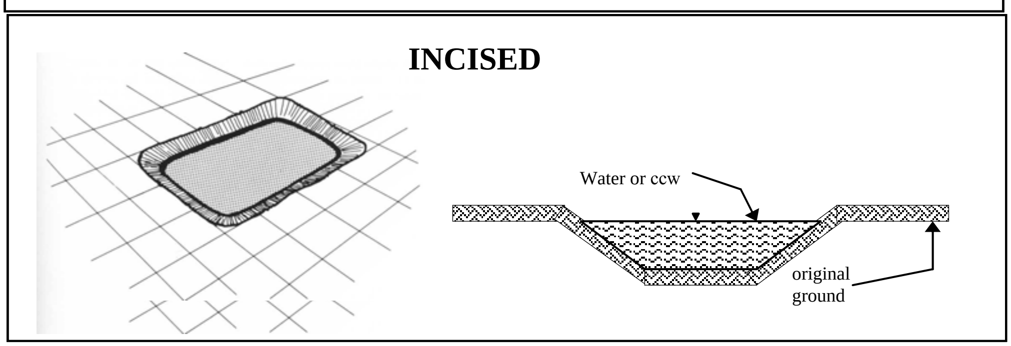
The size of the pond is less than one acre with a storage capacity of approximately 5 acre-feet. In our opinion, failure of the impoundment is not likely to result in loss of human life and environmental damage if any would primarily be limited to the owner's property.

CONFIGURATION:









______ Cross-Valley
______ Side-Hill
______ Diked
______ Incised (form completion optional)
__X__ Combination Incised/Diked

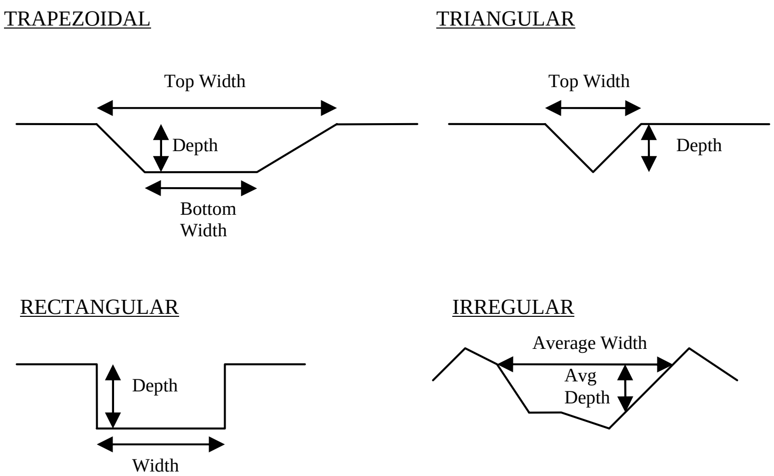
Embankment Height **See Note 1** feet   Embankment Material **Design drawing specifies cohesive fill.**
Pool Area **Less than 1** acres   Liner **See Note 2**
Current Freeboard **Empty at time of inspection** feet   Liner Permeability **Essentially impermeable**

Note 1: Approximately 15 feet along east side only.
Note 2: Design drawing specifies clay subgrade overlain by layered geosynthetics covered by concrete erosion control revetment.

TYPE OF OUTLET (Mark all that apply)

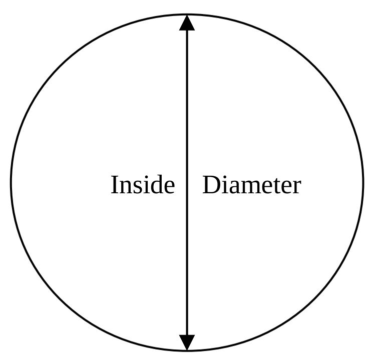
_____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
_____ Rectangular
_____ Irregular

_____ depth
_____ bottom (or average) width
_____ top width



__X__ **Outlet**

__27"__ inside diameter



Material
_____ corrugated metal
_____ welded steel
_____ concrete
__X__ plastic (hdpe, pvc, etc.)
_____ other (specify) ______________________

Is water flowing through the outlet? YES _______ NO __X (Pond essentially empty at time of inspection)

_____ **No Outlet**

_____ **Other Type of Outlet** (specify) ___________________________________

The Impoundment was Designed By **Circa 1992 by Gilbert/Commonwealth, Inc.**

Has there ever been a failure at this site? YES __________ NO ___X______

If So When? ___________________________

If So Please Describe : ____

Has there ever been significant seepages at this site? YES ________ NO __X_____

If So When? ____________________________

IF So Please Describe: ____

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ________NO __X_____

If so, which method (e.g., piezometers, gw pumping,...)? ____________________

If so Please Describe : ____

APPENDIX D

PHOTOS

ASH BASIN NO. 6 IMPOUNDMENT

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Ash Basin No. 6, York Haven, PA	170142.30

Photo No. 1 **Date:** 5/18/2011

Direction Photo Taken: Northwesterly

Description: Overview of Ash Basin No. 6 impoundment.

Photo No. 2 **Date:** 5/18/2011

Direction Photo Taken: Westerly

Description: Overview of west side of Ash Basin No. 6 as viewed from the decant intake structure. Note high vegetation/reeds along inside slope of basin.

Client Name: U.S. Environmental Protection Agency	Site Location: PPL Brunner Island Station Ash Basin No. 6, York Haven, PA	Project No. 170142.30

Photo No.	Date:
3	5/18/2011

Direction Photo Taken:
Northerly

Description:
Overview of east side of Ash Basin No. 6 as viewed from the decant intake structure. Note high vegetation/reeds along inside slope of basin.

Photo No.	Date:
4	5/18/2011

Direction Photo Taken:
Northerly

Description:
Decant intake structure at south end of Ash Basin No. 6. Flow from structure outfalls into the Polishing Pond.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. Environmental Protection Agency	**Site Location:** PPL Brunner Island Station Ash Basin No. 6, York Haven, PA	**Project No.** 170142.30

Photo No. 5	**Date:** 5/18/2011

Direction Photo Taken:
Northwesterly

Description:
Portion of common embankment separating Ash basin No. 6 and the Polishing Pond (shown in foreground). Note Ash Basin No. 6 Water Treatment Building and 48-inch-dameter outfall from Ash Basin No. 6 into Polishing Pond.

Photo No. 6	**Date:** 5/18/2011

Direction Photo Taken:
Northerly

Description:
Outside slope of Ash Basin No. 6 east side embankment taken from the southeast corner of the basin.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name:	**Site Location:**	**Project No.**
U.S. Environmental Protection Agency	**PPL Brunner Island Station Ash Basin No. 6, York Haven, PA**	**170142.30**

Photo No. 7 | **Date:** 5/18/2011

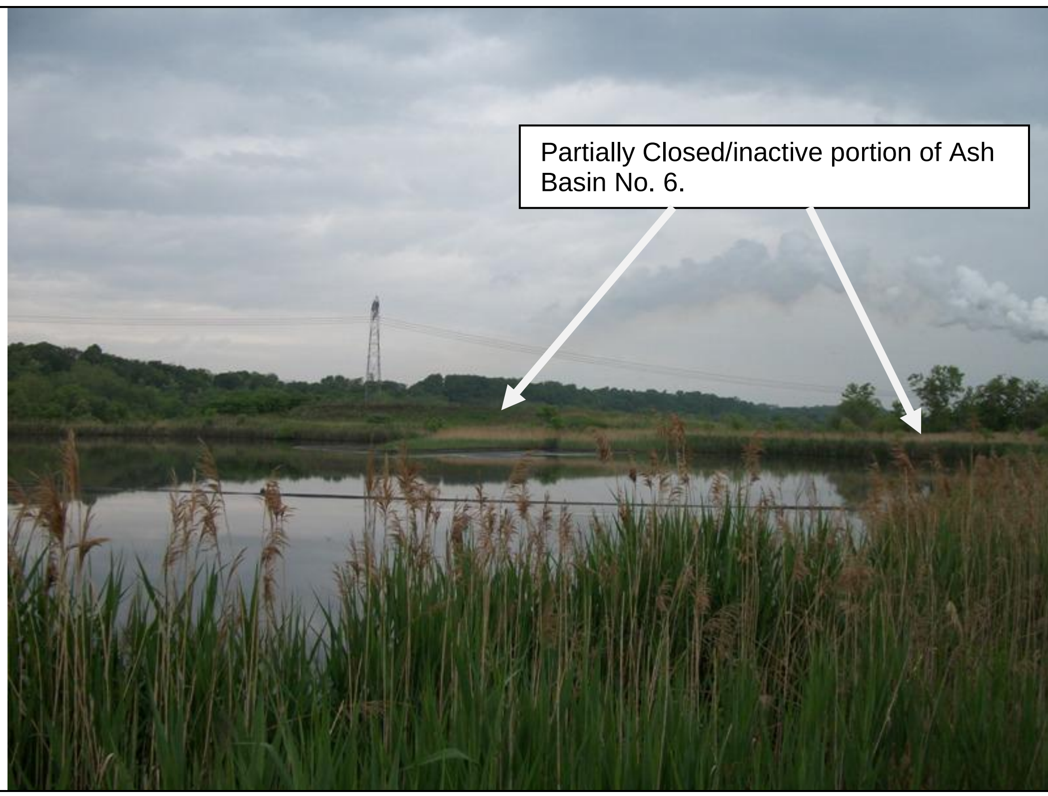
Direction Photo Taken:
Northerly

Description:
Crest of Ash Basin No. 6 east side embankment looking north.

Photo No. 8 | **Date:** 5/18/2011

Direction Photo Taken:
Westerly

Description:
Overview of Ash Basin No. 6 impoundment as viewed from the crest of embankment near the southeast end. Note partially closed/inactive portion of basin beyond the far shore.



Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Ash Basin No. 6, York Haven, PA	170142.30

Photo No.	Date:
9	5/18/2011

Direction Photo Taken:
Southerly

Description:
View of water portion of Ash Basin No. 6 looking southwest. Note decant intake structure.

Photo No.	Date:
10	5/18/2011

Direction Photo Taken:
Westerly

Description:
Transition area between partially closed/inactive and water portion of Ash Basin No. 6 from embankment crest at east end.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Ash Basin No. 6, York Haven, PA	170142.30

Photo No.	Date:
11	5/18/2011

Direction Photo Taken:
Northwesterly

Description:
Overview of partially closed/inactive portion of Ash Basin No. 6 along the east side of the north end of the basin.

Photo No.	Date:
12	5/18/2011

Direction Photo Taken:
Northeasterly

Description:
Outside slope along east side embankment near southeastern end. Heavy tree/forest growth abuts toe of embankment along the majority of the east side. Note water through/beyond the trees is the Susquehanna River.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. Environmental Protection Agency	**Site Location:** PPL Brunner Island Station Ash Basin No. 6, York Haven, PA	**Project No.** 170142.30

Photo No. 13 **Date:** 5/18/2011

Direction Photo Taken:
Westerly

Description:
Standing water observed just beyond toe of east side embankment. According to Plant Representatives this water is likely remnants of previous weeks flooding along the Susquehanna River.

Photo No. 14 **Date:** 5/18/2011

Direction Photo Taken:
Southeasterly

Description:
Localized scarp/erosion observed scarp near toe of embankment on the east side.

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Ash Basin No. 6, York Haven, PA	170142.30

Photo No. 15

Date: 5/18/2011

Direction Photo Taken:
Southeasterly

Description:
Perforated CMP near in the area between the toe and the Susquehanna River at approximately the mid-point of the east side embankment. According to review of the design drawings, the pipe appears to be remnants of a temporary sedimentation pond associated with Ash Basin No's 6 original (circa 1978) construction.

Photo No. 16

Date: 5/18/2011

Direction Photo Taken:
Easterly

Description:
View of Ash Slurry Treatment System effluent discharge piping situated at the north end of the basin. Note Ash Basin No. 6 (left side of drive is partially closed/inactive (though not officially capped); Ash Bain No. 5 (right side of drive) has long been capped.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. Environmental Protection Agency	**Site Location:** PPL Brunner Island Station Ash Basin No. 6, York Haven, PA	**Project No.** 170142.30

Photo No. 17	**Date:** 5/18/2011

Direction Photo Taken: Westerly

Description: Decanted effluent discharge outfall from the Equalization Pond. Outfall situated at the north end of the basin.

Photo No. 18	**Date:** 5/18/2011

Direction Photo Taken: Southerly

Description: Decanted effluent from outfall in previous photo meanders its way to the water portion of Ash Basin no. 6 via a channel traversing the partially closed/inactive portion.

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Ash Basin No. 6, York Haven, PA	170142.30

Photo No. 19 **Date:** 5/18/2011

Direction Photo Taken:
Northeasterly

Description:
Outflow from Boiler Unit Nos. 1 and 2 Bottom Ash Slurry Treatment System discharging into the northeast end of (the partially closed/inactive portion) of Ash Basin No. 6.

Photo No. 19A **Date:** 5/18/2011

Direction Photo Taken:
Easterly

Description:
View of Bottom Ash Treatment System. Note angled auger mechanism which serves to separate a majority of the ash from the raw CCW slurry. The separated ash is temporarily stored adjacent to the facility to allow for final drying and then processed on and off-site for beneficial reuse. Effluent slurry from the treatment system is pumped to Ash Basin No. 6.

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Ash Basin No. 6, York Haven, PA	170142.30

Photo No. 19B **Date:** 5/18/2011

Direction Photo Taken: Southeasterly

Description: Overview of auger mechanism and conveyor system which directs separated ash to the temporary storage area (at the right of the photo) for final drying.

Photo No. 19C **Date:** 5/18/2011

Direction Photo Taken: Northerly

Description: Portion of pipe network which routes effluent slurry from Bottom Ash Treatment System to Ash Basin No. 6.

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Ash Basin No. 6, York Haven, PA	170142.30

Photo No.	Date:
20	5/18/2011

Direction Photo Taken:
Southerly

Description:
View of outside slope and toe area beyond along the west side of Ash Basin No. 6 near the north end looking south. Note high vegetation particularly on slope. Annual mowing normally occurs in June.

Photo No.	Date:
21	5/18/2011

Direction Photo Taken:
Northwesterly

Description:
Overview along west side of Ash Basin No. 6 embankment looking north.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Ash Basin No. 6, York Haven, PA	170142.30

Photo No.	Date:
22	5/18/2011

Direction Photo Taken:
Northwesterly

Description:
Close-up view of west side embankment looking north. Note knee-high vegetation precluded close visual inspection. Annual mowing occurs in June.

ASH BASIN NO. 6 (POLISHING POND)

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station (Ah Basin No. 6) Polishing Pond, York Haven, PA	170142.30

Photo No. 23 **Date:** 5/18/2011

Direction Photo Taken:
Southwesterly

Description:
North end of polishing pond as viewed from the crest of the east embankment. Ash Basin No.6 Water Treatment Building (right) conveys water from Ash Basin No. 6 to the Polishing Pond via a 48-inch RCP pipe.

Photo No. 24 **Date:** 5/18/2011

Direction Photo Taken:
Southeasterly

Description:
Overview of the Polishing Pond from northeast end. Note stairway leading down to the impoundment's decant outflow structure.

Client Name: U.S. Environmental Protection Agency	Site Location: PPL Brunner Island Station (Ah Basin No. 6) Polishing Pond, York Haven, PA	Project No. 170142.30

Photo No. 25

Date: 5/18/2011

Direction Photo Taken:
Westerly

Description:
Decant overflow structure Note dual 60-inch-diameter riser pipes and skimmer structure which control level of Polishing Pond.

Photo No. 26

Date: 5/18/2011

Direction Photo Taken:
Northwesterly

Description:
Inside slope of west embankment as viewed from overflow structure. Note stone riprap protection placed as a maintenance action to mitigate erosion along toe.

Client Name:	**Site Location:**	**Project No.**
U.S. Environmental Protection Agency	**PPL Brunner Island Station (Ah Basin No. 6) Polishing Pond, York Haven, PA**	**170142.30**

Photo No.	**Date:**
27	5/18/2011

Direction Photo Taken:
Southeasterly

Description:
Small scarp near waterline observed on inside slope on east side.

Photo No.	**Date:**
28	5/18/2011

Direction Photo Taken:
Southeasterly

Description:
Gate structure for 48-inch discharge pipe from Polishing Pond overflow structure as viewed from crest of east embankment.

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station (Ah Basin No. 6) Polishing Pond, York Haven, PA	170142.30

Photo No.	Date:
29	5/18/2011

Direction Photo Taken:
Southerly

Description:
Outside slope along west embankment. Note knee-high vegetation precluded close visual inspection. Annual mowing occurs in June.

Photo No.	Date:
30	5/18/2011

Direction Photo Taken:
Easterly

Description:
Concrete patch/backfill near toe of embankment at west side of Polishing pond. Concrete apparently placed as part of slope maintenance program.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. Environmental Protection Agency	**Site Location:** PPL Brunner Island Station (Ah Basin No. 6) Polishing Pond, York Haven, PA	**Project No.** 170142.30

Photo No. 31

Date: 5/18/2011

Direction Photo Taken: Southeasterly

Description: Ruts observed along toe of west embankment. It appears that standing water is more a result of recent heavy rainfall rather than seepage through the embankment.

Photo No. 32

Date: 5/18/2011

Direction Photo Taken: Northerly

Description: Gate structure for 48-inch-diameter outfall pipe located on east side of Polishing Pond.

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station (Ah Basin No. 6) Polishing Pond, York Haven, PA	170142.30

Photo No. 33

Date: 5/18/2011

Direction Photo Taken:
Easterly

Description:
Discharge channel which conveys decanted Polishing Pond discharge via the 48-inch-diameter outfall to the Susquehanna River beyond.

Photo No. 34

Date: 5/18/2011

Direction Photo Taken:
Westerly

Description:
View of flap valve over the 48-inch-diameter outfall pipe. Discharge channel flows to the Susquehanna River.

EQUALIZATION POND

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Equalization Basin, York Haven, PA	170142.30

Photo No. 35

Date: 5/18/2011

Direction Photo Taken:
Northerly

Description:
Overview of the Equalization Basin from the southern end. Note concrete erosion control revetment matting along inside slopes.

Photo No. 36

Date: 5/18/2011

Direction Photo Taken:
Northwesterly

Description:
View of west inside slope depicting incised nature of construction. Note discharge pipe from plant storm water runoff.

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Equalization Basin, York Haven, PA	170142.30

Photo No. 37

Date: 5/18/2011

Direction Photo Taken:
Westerly

Description:
Overview of inside slope at south end of Basin.

Photo No. 38

Date: 5/18/2011

Direction Photo Taken:
Northwesterly

Description:
Crest of east embankment as viewed from the south. Note high vegetation/shrubbery along outside slope.

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	**PPL Brunner Island Station Equalization Basin, York Haven, PA**	**170142.30**

Photo No.	Date:
39	5/18/2011

Direction Photo Taken:
Westerly

Description:
North end of equalization Basin. Note slide gate and 24-inch-diameter pipe. Pipe conveys discharge of a portion of the Plant's interior drainage collection system.

Photo No.	Date:
40	5/18/2011

Direction Photo Taken:
Southeasterly

Description:
Outside slope of east embankment as viewed from the north. Shrubbery and high vegetation.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Equalization Basin, York Haven, PA	170142.30

Photo No. 41 **Date:** 5/18/2011

Direction Photo Taken:
Southerly

Description:
View of northern end of the Equalization Basin.

Photo No. 42 **Date:** 5/18/2011

Direction Photo Taken:
Easterly

Description:
Local minor erosion observed along the outside of the east embankment.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Equalization Basin, York Haven, PA	170142.30

Photo No.	Date:
43	5/18/2011

Direction Photo Taken:
Southeasterly

Description:
Toe of eastern embankment slope as viewed from the north. Access road area immediately beyond toe.

Photo No.	Date:
44	5/18/2011

Direction Photo Taken:
Southwesterly

Description:
Toe of southern embankment slope looking west.

INCIDENTAL WASTE TREATMENT BASIN (IWTB)

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name:	**Site Location:**	**Project No.**
U.S. Environmental Protection Agency	**PPL Brunner Island Station Incidental Waste Treatment Basin (IWTB), York Haven, PA**	**170142.30**

Photo No. 45 **Date:** 5/18/2011

Direction Photo Taken:
Northwesterly

Description:
Overview of the south lagoon from the Decant Gate and Sensor Equipment Monitoring Structure. Note north side of north lagoon as well as the east sides of the north, middle and south lagoons are bordered by the Susquehanna Flood Control Levee, the top of which is approximately 11 feet higher than the incised IWTB lagoons.

Photo No. 46 **Date:** 5/18/2011

Direction Photo Taken:
Easterly

Description:
Overview of Decant Gate and Sensor Equipment Monitoring Structure at the southeast corner of the south lagoon. A 36-inch-diameter CMP discharges decanted water to the Susquehanna River. Note water may also be diverted back into the adjacent Intake Water Treatment Plant solids settling basin (located to the right of the dike in photo) for re-treatment as necessary.

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Incidental Waste Treatment Basin (IWTB), York Haven, PA	170142.30

Photo No.	Date:
47	5/18/2011

Direction Photo Taken:
Southwesterly

Description:
Intake Water Treatment Plant solids settling basin situated at the southern most portion of the IWTB. Note water flows to the canal which runs along the west side of the IWTB to the Coal Pile Runoff Treatment Facility.

Photo No.	Date:
48	5/18/2011

Direction Photo Taken:
Southerly

Description:
Stone protection over CMP discharge pipe at eastern end of Intake Water Treatment Plant solids settling basin. Flow through pipe is discharge from the Intake Water Treatment Plant which is located approximately 650 feet southeast of this location.

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Incidental Waste Treatment Basin (IWTB), York Haven, PA	170142.30

Photo No. 49

Date: 5/18/2011

Direction Photo Taken:
Easterly

Description:
Intake Water Treatment Plant solids settling basin viewed from the west end. Note common dike separating the basin and south lagoon (left).

Photo No. 50

Date: 5/18/2011

Direction Photo Taken:
Easterly

Description:
View of inside slope of south side dike at the south lagoon. Note heavy vegetation and shrubbery precluded close visual inspection of slope.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Incidental Waste Treatment Basin (IWTB), York Haven, PA	170142.30

Photo No.	Date:
51	5/18/2011

Direction Photo Taken:
Northeasterly

Description:
(At left) view of inside slope of common dike between the middle and south lagoons. Note heavy shrub/small tree growth and high vegetation. Also note the higher elevation Susquehanna Flood Control Levee in the background which forms the east side of the north, middle and south lagoons.

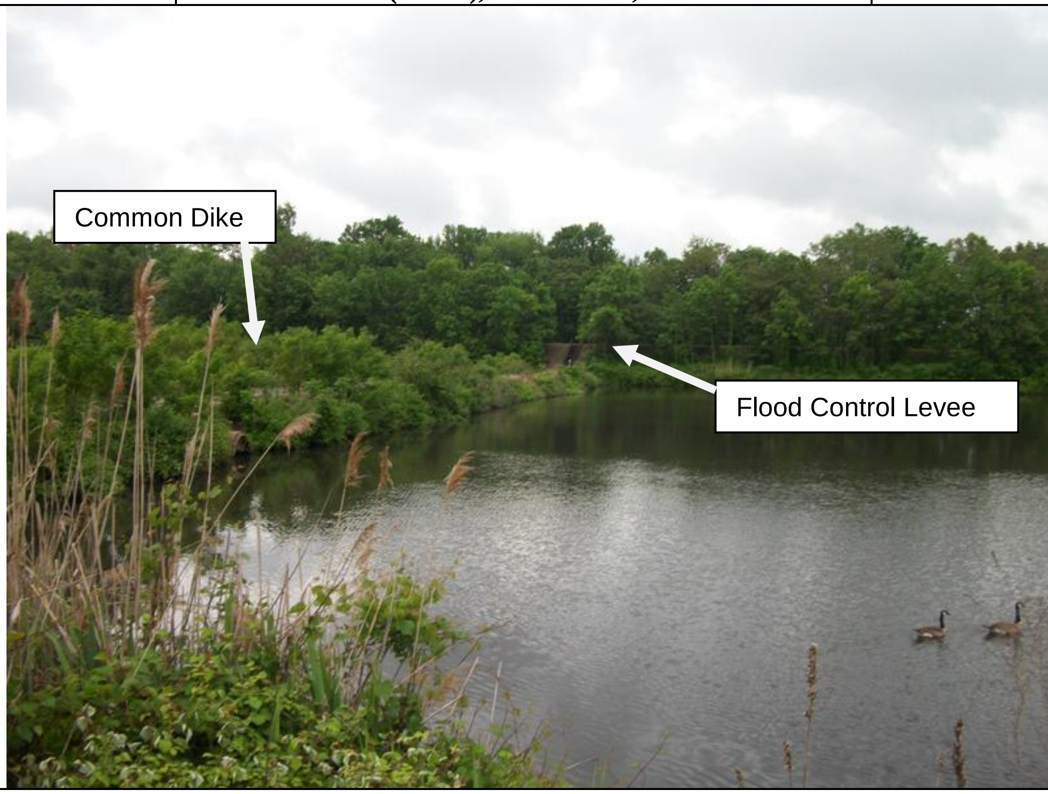


Photo No.	Date:
52	5/18/2011

Direction Photo Taken:
Northeasterly

Description:
Crest of common dike between the middle and south lagoons. Note overgrown vegetation on slopes. Staircase at end of dike leads up to crest of Susquehanna Flood Control Levee which borders the east side of the north, middle and south lagoons.

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Incidental Waste Treatment Basin (IWTB), York Haven, PA	170142.30

Photo No. 53 **Date:** 5/18/2011

Direction Photo Taken:
Southeasterly

Description:
Travel way dike along western side of IWTB. Canal along right side of travel way conveys water to the Coal Pile Runoff Treatment Facility for eventual discharge into the north lagoon.

Photo No. 54 **Date:** 5/18/2011

Direction Photo Taken:
Southwesterly

Description:
Slide gate (normally closed as shown), at western canal allows conveyance of water via a 24-inch CMP to the middle lagoon if necessary.

Client Name: U.S. Environmental Protection Agency	Site Location: PPL Brunner Island Station Incidental Waste Treatment Basin (IWTB), York Haven, PA	Project No. 170142.30

Photo No. 55 | **Date:** 5/18/2011

Direction Photo Taken:
Easterly

Description:
Overview of middle lagoon from western end. Note moderate to heavy vegetation, shrubbery and small trees along inside slopes.

Photo No. 56 | **Date:** 5/18/2011

Direction Photo Taken:
Northeasterly

Description:
Inside slope of common dike between middle lagoon (right) and north lagoon. Note moderate to heavy vegetation, shrubbery and small trees along inside slopes.

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Incidental Waste Treatment Basin (IWTB), York Haven, PA	170142.30

Photo No.	Date:
57	5/18/2011

Direction Photo Taken:
Southeasterly

Description:
Overview of canal along western side of IWTB looking southeasterly. Note minor to moderate erosion/scarps along slope.

Photo No.	Date:
58	5/18/2011

Direction Photo Taken:
Northeasterly

Description:
Crest of common dike between middle and north lagoons. Note moderate to heavy vegetation, shrubbery and small trees along inside slopes.

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Incidental Waste Treatment Basin (IWTB), York Haven, PA	170142.30

Photo No. 59 **Date:** 5/18/2011

Direction Photo Taken:
Northwesterly

Description:
View of Coal Pile Runoff Water Treatment Facility at northwestern portion of the IWTB. Note concrete intake from west side canal (lower left).

Photo No. 60 **Date:** 5/18/2011

Direction Photo Taken:
Westerly

Description:
Intake, from west side canal, to the Coal Pile Runoff Water Treatment Facility.

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Incidental Waste Treatment Basin (IWTB), York Haven, PA	170142.30

Photo No.	Date:
61	5/18/2011

Direction Photo Taken:
Easterly

Description:
Mixing tanks at Coal Pile Runoff Treatment Facility. Note water is discharged from the treatment facility to the north lagoon.

Photo No.	Date:
62	5/18/2011

Direction Photo Taken:
Southerly

Description:
Discharge outfall from Coal Pile Runoff Treatment Facility into the north lagoon. Discharge pipe is fully surrounded by turbidity curtains. Note high vegetation on inside slopes.

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Incidental Waste Treatment Basin (IWTB), York Haven, PA	170142.30

Photo No.	Date:
63	5/18/2011

Direction Photo Taken:
Northeasterly

Description:
North lagoon as viewed from the southwest. North lagoon is bounded on the north and east sides by the Susquehanna Flood Control Levee (mostly hidden just beyond the trees).

Photo No.	Date:
64	5/18/2011

Direction Photo Taken:
Northerly

Description:
View of Susquehanna Flood Control Levee which makes up the north embankment of the north IWTB lagoon (as well as the east side of the north, middle and south lagoons).

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Incidental Waste Treatment Basin (IWTB), York Haven, PA	170142.30

Photo No. 65 **Date:** 5/18/2011

Direction Photo Taken: Southerly

Description: View of north lagoon and the Coal Pile Runoff Treatment Facility.

Photo No. 66 **Date:** 5/18/2011

Direction Photo Taken: Northeasterly

Description: View of the crest along the Susquehanna Flood Control Levee which forms the north embankment of the north lagoon and the east embankment of the north, middle and south lagoons. North lagoon is at right.

Client Name:	**Site Location:**	**Project No.**
U.S. Environmental Protection Agency	**PPL Brunner Island Station Incidental Waste Treatment Basin (IWTB), York Haven, PA**	**170142.30**

Photo No. 67

Date: 5/18/2011

Direction Photo Taken:
Southerly

Description:
Overview of north lagoon as viewed from the crest of the Susquehanna Flood Control Levee. Note middle pond is at left.

Photo No. 68

Date: 5/18/2011

Direction Photo Taken:
Southwesterly

Description:
Overview of common dike between the middle and north lagoons from the crest of the Susquehanna Flood Control Levee. Note moderate to locally heavy erosion, scarps and high vegetation along both sides of dike.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name:	Site Location:	Project No.
U.S. Environmental Protection Agency	PPL Brunner Island Station Incidental Waste Treatment Basin (IWTB), York Haven, PA	170142.30

Photo No. 69 **Date:** 5/18/2011

Direction Photo Taken:
Southwesterly

Description:
Overview of common dike between the south and middle lagoons from the crest of the Susquehanna Flood Control Levee. Note the ground water quality testing well in the foreground.

Photo No. 70 **Date:** 5/18/2011

Direction Photo Taken:
Southeasterly

Description:
View of south lagoon from common dike between the south and middle lagoons. Note Decant Gate and Sensor Monitoring Structure at left side.

APPENDIX E

REFERENCES

PREVIOUS REPORTS AND REFERENCES

The following is a list of drawings and related information that was located during the file review, or was referenced in previous reports.

1. HDR Engineering, Inc., Slope Stability Assessment Brunner Island Ash Basin No. 6, December 2009. (Attached herein).

2. HDR Engineering, Inc., 2010 Annual Inspection Report Brunner Island Ash Basin No. 6, December 2010.

3. HDR Engineering, Inc., 2009 Annual Inspection Report Brunner Island Ash Basin No. 6, November 2009.

4. Borings, Soil & Testing Company Geotechnical Engineers, Report on Investigation of Foundation Conditions for Ash Storage Basins 6 and 7 Brunner Island S.E.S., August 1977.

5. Power Plant Engineering Development, Initial Inspection Report Brunner Island SES Ash Basin No. 6, June 1981

6. PADEP, Form 1R Facility Plan For Residual Waste Facility, PPL Generation, LLC.

7. PADEP, Form 12R Operation Plan – Phase II, PPL Generation, LLC.

8. Pennsylvania Power & Light Company, Drawing E158596-4, Brunner Island S.E.S., Ash Basin No. 6 And Polishing Pond Plan & Sections, January 1978.

9. Pennsylvania Power & Light Company, Drawing E158596-6, Brunner Island S.E.S., Ash Basin No. 6 And Polishing Pond Plan & Sections, January 1978.

10. Pennsylvania Power & Light Company, Drawing E-178085, Brunner Island S.E.S., Ash Basin No. 6 – Polishing Pond Enlarged Plan, June 1979.

11. Schnabel Engineering, Geotechnical Engineering Report, PPL Brunner Island SES Transient Seepage and Slope Stability Study (Reference 116151019), February 17, 2012. (Attached herein).

The following references were utilized during the preparation of this report and the development of the recommendations presented herein.

1. USACE, "Recommended guidelines for safety inspection of dams," EM 1110-2-106, 1979.

2. FEMA, "Federal Guidelines for Dam Safety," May 2005.

3. Pennsylvania Code Title 25, Chapter 105, Dam Safety and Waterway Management

SLOPE STABILITY ASSESSMENT
BRUNNER ISLAND ASH BASIN NO. 6

Prepared for:
PPL GENERATION, LLC
Allentown, Pennsylvania

Prepared by:
HDR ENGINEERING, INC.
Portland, Maine

DECEMBER 2009

SLOPE STABILITY ASSESSMENT
BRUNNER ISLAND ASH BASIN NO. 6

TABLE OF CONTENTS

SLOPE STABILITY ASSESSMENT
BRUNNER ISLAND ASH BASIN NO. 6

LIST OF TABLES

Section 1
Executive Summary

PPL Generation, LLC (PPL) owns and operates Ash Basin No. 6 at their Brunner Island Steam Electric Station located in Manchester Township, Pennsylvania. HDR|DTA performed dam safety inspections of Brunner Island Ash Basin No. 6 in 2008 and 2009, as required by Pennsylvania Department of Environmental Protection (PADEP) regulations.

During the annual inspections of Brunner Island Ash Basin 6, several slope stability issues were identified. These included:

- Evidence of past slope sloughs at the north and south ends of the east embankment and at the north end of the west embankment. The sloughs were generally shallow, less than 3 feet deep, and reportedly occurred during recedance of flooding on the Susquehanna River.
- Puddled water and other evidence of seepage were observed extending approximately 1/3 of the way up the slope from the toe along the eastern embankment. This degree of seepage was considered to be a concern for a 2:1 slope. Note that PPL reported that this seepage was not evident in July 2008.
- The proximity of the ash basin slopes to the Susquehanna River creates the potential for recurring rapid drawdown conditions on the downstream slope due to significant, rapid-stage changes as a result of flooding.
- A topsoil and ash stockpile adjacent to the west embankment will surcharge the adjacent slope, although this effect is limited to a small portion of the overall embankment. PPL has reported that the slopes of this stockpile have since been cut back.

As a result of these observations, a recommendation was presented in the 2008 inspection report that the stability of the ash basin perimeter dike be reviewed and assessed in greater detail. Analyses from the original design were not available for review, although foundation boring logs, construction drawings and specifications, and field compaction test results were available. HDR|DTA performed preliminary slope stability analyses of the embankment using assumed soil parameters and groundwater assumptions. These analyses indicated that the stability of the embankment could be deficient and more detailed exploration and analyses were warranted.

A reconnaissance level field and laboratory geotechnical investigation was conducted in the summer of 2009. A total of four test borings were drilled at two cross sections on the east embankment that were identified as being potentially critical. Field and laboratory strength testing was performed, and piezometers were installed in each boring. The drilling program found that the embankment was constructed of dense silt, sand, and gravel with lenses of material varying from hard clay to gravel. The foundation soils consisted of stiff to very stiff clayey silt and silty clay, and moderately dense to dense silty sand. The phreatic surface varied between the two sections, with the phreatic surface at the north section of the east embankment significantly higher than in the middle. The north section was adjacent to an area where sloughs had occurred previously.

Slope stability analyses were conducted using the site specific strength and piezometric data. The factors of safety for the downstream embankment slope were found to be slightly less than the accepted values for the normal operating and surcharge (full basin) conditions, but were considered acceptable.

The factor of safety for the rapid drawdown condition, which would occur during the recession of major flooding on the Susquehanna River, was marginal. The slip surfaces for both the 100- and 500-year floods with factors of safety of 1.0 extended to the crest of the embankment, with a deep failure surface extending through the entire crest of the embankment for the 500-year flood. The failure surface for the 500-year flood in particular, is deep enough that an embankment breach could result. The recommended factor of safety for the rapid drawdown condition is between 1.1 and 1.3 for embankment dams, and 1.0 for levees. The relatively low required factors of safety recognize that the drawdown analysis requires that a number of simplifying assumptions be made, which tend to be conservative. PPL noted that ash basins No. 4 and 5, which are of similar design, were subject to extreme flooding in 1972 as a result of hurricane Agnes without experiencing significant slope failures. The peak flow was reportedly close to the 500-year flood level, and the peak stage was close to the top of the dikes.

Based on the results of the analysis, the occurrence of sloughs in the recent past, the service life that will be required of the closed ash basin, and the economic and ecological consequences associated with a breach of the embankment and release of ash; remediation of the embankment is warranted. The remediation would likely consist of construction of either a stabilization berm or shell, constructed of free-draining gravel. The cross section of the embankment is generally consistent around the ash basin, and the west embankment will also be exposed to river flooding, so that the berm will likely be needed over most of the perimeter, which would be a significant project. A filter would be incorporated into either option to address seepage. Additional investigation would be appropriate to account for variations in embankment fill properties and groundwater conditions. Scour and erosion resulting from flood flows should also be considered as part of the remediation. PPL noted that a scour study was completed in 2007, and concluded that scour would not be a problem as a result of very low velocities along the shoreline.

Conversely, additional analyses could be performed to assess the transient seepage conditions which may determine that an embankment breach as a result of drawdown would not occur. These analyses are not straightforward, and there are a number of variables that would need to be considered.

Until a final stabilization plan is implemented, PPL should consider the following:

- Repair the existing sloughed areas.
- Drawdown the reservoir if significant tailwater flooding is forecast. While this is not expected to have a major effect, it may reduce the likelihood of progressive failure.
- Continue monitoring piezometers on a monthly basis until annual trends can be established.

Section 2
Background

Brunner Island Ash Basin No. 6 is an oval-shaped, man-made reservoir constructed to contain and store coal ash slurry. A plan of the ash basin and original construction drawings are provided in Appendix A. The ash basin consists of an earth embankment perimeter dike that is approximately 8,300 feet in circumference and has a maximum height of the downstream slope of about 30 feet. The crest of the embankment is at elevation 290 feet. The surface area is about 70 acres, and the storage capacity at the crest of the embankment is about 2,600 acre-feet. The ash basin was constructed in 1979 and is due to be retired in 2011. After retirement, the basin will continue to store partially consolidated coal ash slurry.

The majority of the embankment was constructed of native sandy silt to silty clay compacted to at least 95 percent of the maximum density determined in accordance with ASTM standard D698, the Standard Proctor test. A 10-foot-thick clay blanket was constructed on the upstream face of the embankment, extending from elevation 287.5 feet (2.5 feet below the crest) to rock. Compaction tests are available indicating that the embankment was constructed substantially in accordance with the specifications. The basin contains two intermediate dikes that divide the basin into three sub-basins. The northernmost sub-basin is essentially filled with ash, although slurry is still routed through it, maintaining it in a saturated state. The center basin is partially full, and the southern basin, referred to as the polishing pond, is used for final clarification of free water before it is discharged to the Susquehanna River. The Susquehanna River is located approximately 80 feet east of the ash basin at its closest point, and flooding from the Susquehanna periodically extends up the embankment slopes. The ash basin falls under the jurisdiction of the PADEP with respect to dam safety. The dam is classified as a medium-sized, significant-hazard-potential structure, referred to as size B-2 using PADEP terminology. PADEP requires that the dam be inspected quarterly and has established safety requirements, although the performance criteria have not been established.

HDR|DTA performed annual inspections for PPL in 2008 and 2009. Several slope stability issues were identified during these annual inspections. These included:

- Evidence of past slope sloughs at the north and south ends of the east embankment and at the north end of the west embankment. The sloughs were generally shallow, less than 3 feet deep, and reportedly occurred during recedance of flooding on the Susquehanna River.
- Puddled water and other evidence of possible seepage (or soil saturation) were observed extending approximately 1/3 of the way up the slope from the toe along the eastern embankment. This degree of saturation was considered to be a concern for a 2:1 slope. Note that PPL reported that this wetness was not evident in July 2008, and the saturation observed in the 2009 inspection was not as extensive as that observed in 2008, possibly because the river hadn't recently flooded and there hadn't been as much recent rainfall. The inspection was conducted in late May in 2009, as opposed to late April in 2008, and there may also be seasonal differences in embankment saturation.
- The proximity of the ash basin slopes to the Susquehanna River creates the potential for recurring rapid drawdown conditions on the downstream slope due to significant, rapid stage changes as a result of flooding.
- A topsoil and ash stockpile adjacent to the west embankment will surcharge the adjacent slope.

As a result of these observations, a recommendation was presented in the 2008 inspection report that the stability of the ash basin perimeter dike be reviewed and assessed in greater detail. Analyses from the original design were not available for review, although foundation boring logs, construction drawings and specifications, and field compaction test results were available. HDR|DTA performed preliminary slope stability analyses of the embankment using assumed soil parameters and groundwater assumptions. These analyses indicated that the stability of the embankment could be deficient and more detailed exploration and analyses were warranted.

PPL requested that HDR|DTA perform an assessment of the stability of the embankment, which included the development and coordination of a subsurface and laboratory investigation program. Construction drawings, specifications, and compaction test results were provided by PPL, but the original slope stability analyses and assumptions were not available. The subsurface investigation program conducted in June 2009 served to gather information on in situ soil strength parameters and groundwater conditions for the embankment sections determined to be critical during the 2009 annual inspection.

Section 3

Subsurface Investigation

3.1 Embankment Geometry

The embankment cross section is generally consistent all of the way around, with the following differences:

- The embankment height varies from essentially zero at the north end of the embankment to approximately 30 feet at the middle of the east embankment. Natural ground at the west embankment is generally higher than at the east embankment, although the west embankment is still exposed to flooding from the Susquehanna River.
- The upstream water level is highest in the northern sub-basin, approximately 1 to 2 feet higher than the middle basin, at about elevation 288 feet. This is high enough to overtop the upstream clay liner. The water level in the center basin is normally about 287 feet. The water level in the polishing pond is normally slightly above the intake pipe top elevation of 268 feet.
- There is an 18-foot-high fill stockpile on the west embankment near Sta 11+00. Because this is a local occurrence, this section was not chosen for analysis.

Two embankment sections were chosen for exploration, as shown on the plan in Appendix A. Photos of the embankment sections are provided in Appendix B. These sections were believed to be critical based on observations made during the annual inspections, as noted below.

East Embankment at Station 21+80, Section 1-1 – This section was located immediately south of the series of shallow sloughs described previously. The location where the holes were drilled obviously has a somewhat higher factor of safety with respect to shallow slides than the slide area, but the expectation is that this section was likely marginally stable at the time the adjacent sections slid. Wet soils were observed on the embankment face approximately 1/3 of the way up the slope and the toe was saturated, possibly indicating a high phreatic surface. A channel carrying free water is present at the upstream face. The section height is approximately 25 feet, slightly less than the maximum section height.

East Embankment at Station 7+44, Section 2-2 – The section height is approximately 30 feet, which is near the maximum height of the downstream slope. The toe of the embankment was observed to be wet at this location with intermittent puddles of standing water near the base of the slope, extending 5 feet up the slope. Water was observed actively seeping from the slope at and near the location of Boring B09-4 and could be audibly heard as it trickled down the slope. The toe was saturated. These observations were not consistent with the piezometer readings, which show the phreatic surface below the ground surface at Sta 7+44. It is apparent that phreatic conditions are not straightforward, as discussed later. Saturation of the slope and toe may be the result of rainfall and high river levels, although there is not enough piezometric data to assess seasonal trends. Open water in the middle sub-basin extends to the upstream face.

Note that the stability of the splitter dike between the middle sub-basin and the polishing pond was not assessed during this study. The splitter dike is totally contained within the perimeter dike, and a breach of the splitter dike would not result in an uncontrolled release of ash, providing the discharge conduit was closed.

3.2 Geotechnical Exploration

Four borings were drilled in the east embankment. Two borings were located at approximate station 7+44 (Section 2-2), and an additional two borings were located at approximate station 21+80 (Section 1-1). At each station, one boring was drilled in the crest through the existing access road, and the second boring was drilled from the slope near the downstream toe of the embankment. Subsurface exploration and piezometer installation was performed by Cumberland Geoscience Consultants (CGC), contracted to PPL. Geotechnical engineering observation, borehole logging, and piezometer installation coordination was provided by a geotechnical engineer with HDR|DTA. Drilling work started on Monday, June 8, 2009 and was completed on Thursday, June 18, 2009.

Borings located at the crest of the embankment were drilled using a truck-mounted Acker SoilMax drilling rig using 4-1/4-inch-diameter, hollow-stem augers (B09-1 and B09-3).

Benches were cut in the slope at B09-2 and B09-4 to provide relatively flat working areas to set and support the skid rig. The bench was dug by a PPL Contractor using a large excavator working from the perimeter road at the top of the slope. Bench dimensions were approximately 2 to 3 feet in height and 5 to 6 feet in width, measured perpendicular to the axis of the embankment. The upper 2 to 3 feet of the slope was generally observed as wet to saturated during excavation of the bench area. Below a depth of 2 to 3 feet, the soil was typically moist to dry with zones of wet soil.

Boring locations on the downstream slope were accessed by winching the skid-mounted rig from the perimeter road down the slope to the excavated working area. A perimeter guard rail consisting of I-beam posts with steel cable strung between posts was located along each side of the perimeter road. The guard rail cable on the downstream side of the road was removed prior to winching the rig off the crest. The skid-rig was then winched down the slope with the help of the excavator which was used to help stabilize the rig during winching.

Borings located on the downstream slope were drilled using a skid-mounted Sprague and Henwood 40C drilling rig using a 3-7/8-inch-diameter tri-cone bit and rotary drilling methods (B09-2 and B09-4). Four-inch internal diameter steel casing was advanced in holes completed with rotary drilling methods.

Following completion of borehole drilling and installation of the piezometer, the skid-rig was winched off of the borehole location and back up the slope. The excavated soil materials were replaced in the excavated area and lightly compacted by tamping with the backhoe bucket. PPL re-attached the guard rail cable.

Sampling was performed at selected depth intervals designated by the geotechnical engineer. Sampling was completed using a Standard Penetration Test (SPT) split-spoon sampler driven 24 inches using a 140-pound safety hammer. At selected locations and depths where cohesive soils were encountered, 3-inch-diameter thin-walled tube samples were attempted. Bulk samples consisting of auger cuttings from selected depth intervals of the embankment fill were also obtained at Boring B09-1. Samples were logged, classified in the field, photographed, and placed in clean glass jars for later laboratory testing. Boring logs were maintained in the field by the on-site geotechnical engineer.

Borehole termination was based on refusal to either the drilling equipment, SPT sampler, or based on observation of rock or weathered rock materials in recovered samples. Upon completion of drilling to the required depth, one-inch-diameter piezometers were installed with screened depth intervals selected by the geotechnical engineer.

Soil materials were generally granular consisting of silt, sand, and gravel. Fill materials were generally classified as gravelly silt with sand, sandy silt with gravel, or silty sand with gravel. Fill materials contained zones of material that ranged from gravel to clay. Changes in moisture content were often observed at these zones where water was often visible in granular zones above or between silt or clay zones. A layer of natural clayey silt (ML) or silty clay (CL) soil was observed below the fill at most of the borings. Silty sand (SM) with gravel was often present beneath the clayey silt or silty clay material. Partially weathered rock materials, assumed to consist of mudstone or sandstone based on recovered fragments, were encountered below the soil materials near the termination of the borings.

Boring logs were prepared based on the field observations and measurements obtained by the HDR|DTA field engineer and are provided in Appendix C.

3.3 Piezometer Construction

Open standpipe piezometers were installed in all four borings. Generally, a single piezometer was installed with the screen interval slightly below the depth where wet soil materials or water were observed during drilling. Two piezometers were installed in Boring B09-3.

Piezometers were constructed by first using bentonite chips to fill and seal the borehole below the selected piezometer elevation. Filter sand (No. 00) was next placed in the borehole to the bottom of the selected screen depth. A 1-inch-diameter PVC piezometer pipe was then placed in the borehole and additional sand was placed to the selected height above the screen. Bentonite chips were then placed to seal the borehole above the sand filter. Bentonite chips were placed to within a few feet of the borehole surface where sand or drill cuttings were then placed to complete the installation.

Flush mount covers were installed for piezometers B09-3A/3B and B09-1 located in the perimeter road. A one-inch-diameter drain pipe was extended from inside the flush mount cover, below the level of the piezometer cap, to daylight near the top of the downstream slope. This was installed to keep the road boxes from filling with water and influencing the piezometers in the event of puddles or standing water on the crest road. Standpipe protective covers were installed for piezometers B09-2 and B09-4 located near the downstream toe. Cement was placed around the flush mount or standpipe cover to secure the cover in place. PVC caps were placed on top of the PVC piezometer risers inside the covers to keep out dirt and debris.

Details on piezometer construction depths are provided on the individual boring logs provided in Appendix C. Daily measurements of installed piezometers were obtained by the HDR|DTA geotechnical engineer during drilling of the remaining boreholes. Ongoing measurement of the piezometers is being performed by PPL. Plots of piezometric elevation versus time are provided in Appendix F. The three piezometers at Sta 7+44 toe of the embankment, (B-3A, B-3B, and B-4), most recently indicated that the phreatic surface was below the bottom of the piezometer, yet the ground surface at the toe was wet. It is apparent that the native sand layer observed in the borings is acting as a drain.

Section 4
Stability Analysis Criteria

PADEP Code 105.97 requires that the stability of jurisdictional dams be assessed, but does not stipulate analysis methodology or criteria. For the purposes of this analysis, the methodology and criteria in U.S. Army Corps of Engineers (USACE) Engineering Manual EM 1110-2-1902 (Revised October 31, 2003) Slope Stability and EM 1110-2-1913 (Revised April 30, 2000) Design and Construction of Levees were used. The loading conditions stipulated by USACE are described below, along with reservoir and tailwater levels, the recommended analysis method, required factor of safety for each loading condition, and the reference for each parameter. USACE notes that a deformation-based seismic analysis method is being developed, but has not yet been issued. Seismic analyses were performed using the Blake equivalent pseudo-seismic coefficient method, a deformation-based analysis, as described in "Guidelines for Evaluating and Mitigating Seismic Hazards in California." (Special Publication 117, Page 29 of California Geological Survey 2008).

Critical Section - Section 1-1, located at Station 21+80

The piezometric levels at Section 1-1 are noticeably higher than at Section 2-2. Also, the ash basin at Section 1-1 has essentially been filled, while there is an open pool at Section 2-2. Otherwise, the two sections are essentially the same. The cause of the variation in phreatic surfaces has not been explained, but could be due to the fact that the free water level against Section 1-1 may be slightly higher than at Section 2-2, which may overtop the upstream clay liner. Variation in the fines content of the embankment fill material, especially the higher fine contents at Section 1-1, may also partially explain the higher embankment phreatic level. Note that there are likely sections with phreatic surfaces that are higher than that encountered at Section 1-1, and this warrants some conservatism when interpreting the stability analysis results.

Section Geometry

Upstream embankment slope: 2.5:1 (Drawing E158595)

Downstream slope: 2:1 (Dwg E158595, field verified with an inclinometer May 1, 2008)

Crest Width: 15 feet (Drawing E158595, field measured as 19 feet on May 28, 2009)

Crest Elevation: 290 feet (Drawing E158595), NGVD 1929

Toe Elevation: 265 feet (Drawing E324218)

Piezometer locations/elevations: Determined with a tape and pop level, May and June, 2009)

Loading Conditions – Downstream slope only

Normal Operating Condition (Steady Seepage)

Headwater: 288.0 feet (PADEP Dam Inspection Checklist, 2008)

Tailwater: None

Phreatic conditions: Based on piezometer readings at Section 1-1, 9/16/2009. Piezometer readings are based on limited data recorded in June, July, and September 2009. Additional data should be obtained when available.

Analysis Method: Drained (EM 1110-2-1902 Table 2-1, p. 2-2)

Required Factor of Safety: 1.5 (EM 1110-2-1902 Table 3-1, p. 3-2), and PADEP Residual Waste Regulation guidelines.

Note that PPL plans to lower the normal operating level from 288.0 feet to 287.3 feet in 2010. The water level at the time of the 2009 inspection was at Elevation 286.9 feet. The operating level is measured at the downstream (south) end of the open water part of the basin. The elevation of free water at the upstream end of the basin, near the ash sluicing operation, is somewhat higher as evidenced by the visible gradient in the discharge channel; but it has not been measured. Despite the filling of the northern portion of the ash basin, a discharge channel near Section 1-1 provides free water close to the upstream face of Section 1 1, and there is free water at the upstream face of the embankment at Section 2-2.

Maximum Surcharge Pool

Headwater: 289.0 feet (assumed as 1 foot below top of dike)

Tailwater: None

Phreatic conditions: Based on piezometer readings at Section 1-1, 9/16/2009, scaled up to account for the 1-foot reservoir rise and probable variation in the fill permeability.

Analysis Method: Drained (EM 1110-2-1902 Table 2-1, p. 2-2)

Required Factor of Safety: 1.4 (EM 1110-2-1902 Table 3-1, p. 3-2 – Consider as Surcharge Pool.)

The potential for overtopping the embankments was identified as a concern in the annual dam safety inspections. The basin does not have any drainage area other than the basin itself, so that there are no flood runoff issues, except within the basin. All water into the basin is either rainfall falling directly on the basin, or is discharged with pumped sluice lines. PPL intends to install level monitoring devices at the sluice discharge points, in addition to their normal monitoring program. PPL has verified that the level monitoring coupled with the operators' daily inspection rounds will prevent overtopping of the embankment. Therefore, the surcharge condition has been assumed as a 1-foot rise above the normal reservoir level, and it has been assumed that this condition would be observed and remedial measures taken before it rises further. The piezometer response to changes in phreatic surface is unknown; therefore, it has also been assumed that the rise in phreatic surface associated with this surcharge will be linear and proportional, varying from one foot above the measured piezometric head at the embankment center to downstream ends. This may be somewhat conservative, since it is likely that the surcharge level will not be maintained long enough for phreatic surface conditions to stabilize. However, extrapolating the higher-than-measured phreatic surfaces allows determination of the factor of safety at locations where the phreatic surface may be higher than Section 1-1 or for a seasonal or future increase in the existing piezometric head.

Maximum Tailwater – This is the first stage of three-stage rapid drawdown analysis for evaluation of the stress state in embankment

Headwater: 288.0 feet (PADEP Dam Inspection Checklist, 2008)

Tailwater: 278.2 and 288.8 (100-year and 500-year flood tailwater elevation per PPL email 9/17/2009 – PPL has requested that both flood levels be evaluated)

Phreatic conditions: The assumed embankment piezometric head is the highest value of the measured phreatic surface for the normal loading condition and the head corresponding to the 100-year tailwater at the toe. The approximate steady state seepage profile varies from normal headwater upstream to the center of embankment at elevation 278.2 (for the 100 year flood) and remains horizontal to the tailwater at the toe. For the 500 year flood, the phreatic surface is assumed to be level at 288 feet throughout the embankment.

Analysis Method: Drained (EM 1110-2-1913 Table 6-1b, p. 6-5)

The rapid drawdown condition for the downstream slope of an embankment is an unusual loading condition for which there are no established criteria. PPL has requested that the design flood recurrence interval consider both the 100-year and 500-year floods. The flood condition is likely transient enough that phreatic levels will not stabilize at the maximum tailwater level; however, a transient analysis of phreatic surface conditions would likely be both complicated and inaccurate, due to the lack of field data, variability of the embankment fill material, and the required assumptions for duration of flood and variation of the flood level with time. It is noted in EM 1110-2-1902 that a transient phreatic surface analysis is beyond the current state of the art. Modeling the changes in phreatic surface as steady state is conservative, while having a drawdown condition on the downstream slope, as opposed to the upstream slope where it is normally performed, results in a more severe loading condition. The Factor of Safety is not relevant to this condition, but this analysis is the first step in the rapid drawdown analysis.

Rapid Drawdown – These are the second and third stages of analysis.

Headwater: 288.0 feet (PADEP Dam Inspection Checklist, 2008)

Tailwater: 278.2 and 288.0 (100-year and 500-year flood tailwater elevation per PPL email 9/17/2009)

Toe elevation: 265.2 – base of slope after drawdown (Drawing E324218)

Normal river level: 252 +/- (from Drawing 158595)

Phreatic conditions: Assumed steady state associated to the final stage of drawdown, i.e., identical to the normal loading condition.

Analysis Method: Three-stage method (EM 1110-2-1913 Table 6-1b, p. 6-5) based on minimum of undrained and drained strength along the critical failure surface.

Required Factor(s) of Safety:

1.1 (EM 1110-2-1902 Table 3-1, p. 3-2)

1.0 (EM 1110-2-1913-Table 6-1a, p. 6-4 – Consider as drawdown for conditions where the flood level does not persist for a long period preceding drawdown.)

Earthquake

Headwater: 288.0 feet (PADEP Dam Inspection Checklist, 2008)

Tailwater: None

Maximum Peak Ground Acceleration (PGA): 0.105 g (corresponds to 2% probability of exceedance in 50 years according to USGS 2002 data)

Analysis Method: A two-stage method using pseudostatic analysis and Newmark's cumulative displacement analysis. Using Blake's screening analysis procedure (SP117A, p. 30), a site seismicity factor of approximately 0.6 is estimated, assuming a Magnitude 7.0 earthquake, an epicentral distance of 20 km, and a threshold displacement of 5 cm. This results in a seismic coefficient K_{eq} = 0.06g to be used in both the pseudostatic analysis and in the displacement analysis.

Required Factor of Safety: 1.2 (based on PADEP Residual Waste Regulations) and a cumulative displacement of less than 1.0 feet.

Strength Parameters

One suite of three isotropically consolidated undrained triaxial tests was performed on a reconstituted sample of the embankment fill from Section 1-1, Boring B09-1, at a depth of 15 to 19 feet. The sample was compacted in the lab to a density of 95.4 to 98 percent of optimum, as determined using the Standard Proctor test (ASTM D698) with a moisture content of 8.3 percent, near the optimum of 8.1 percent. The degree of compaction and moisture content with respect to optimum is consistent with the original (1979) specifications and field test results; however, the dry density of the tested samples was 123.5 to 126.9 pounds per cubic foot, which was considerably higher than the field tests, and the moisture content was considerably lower.

The triaxial testing results determined that ϕ'= 39.5 degrees, and c' = 0. The three tests were in close agreement with respect to a straight line plot of the effective stress envelope. This value of ϕ' is fairly high, and one suite of tests obviously will not capture the likely range of variations. The Standard Penetration Test blow count "N" value that would correspond to a friction angle of 39.5 degrees is more than 40 blows per foot, which was observed in approximately half of the SPTs. A lower friction angle of 37 degrees, based on an N value of 30 corresponding to the lower range of measured N values, is considered reasonable. The consolidated undrained strength parameters indicate zero cohesion and an undrained friction angle of 24 degrees.

To provide a check of the strength parameters, the friction angle of the embankment was back calculated for the rapid drawdown condition that corresponded to the highest tailwater level in the last 5 years when the slope sloughing was believed to have occurred. A tailwater elevation of 274.1 feet was reported on September 20, 2004. A target factor of safety of 1.0 was selected, consistent with the fact that shallow slope failures did occur, but not over the entire embankment and not at Sta 21+80. An effective friction angle of 37 degrees and cohesion of 0, and an undrained cohesion of 0 and friction angle of 24 degrees resulted in a factor of safety of 1.01, with a failure surface about 3 feet deep, consistent with field observations. Based on this evaluation, a drained friction angle of 37 degrees and an undrained friction angle of 24 degrees were adopted for the remainder of the analyses.

The foundation material is a combination of clay, silt, and sand. The SPT N values were significantly lower in the foundation than in the embankment, and moisture contents were higher. Although the embankment was likely constructed of material similar to the foundation, it is likely that the embankment soils have been compacted to a higher in-situ density and are closer to the optimum moisture content; therefore, the strength of the embankment will be higher than the foundation. The unconfined compressive strength of the silt and clay foundation material based on the N values, field torvane tests, and pocket penetrometer tests was estimated at 4,000 psf. While the majority of the foundation soils encountered in the 2009 borings consisted of stiff to very stiff silts and clays which may have cohesion, sand and gravel lenses were encountered in each of the borings, and in the majority of the borings drilled prior to construction. Due to the variability of the foundation soil materials and properties, and the limited impact of foundation strength parameters on the critical drawdown analysis, more detailed testing and strength parameter determination was not considered warranted for the foundation soils. An effective friction angle, ϕ' of 30 degrees, and cohesion, c = 0 psf was assumed, based on correlations of effective friction angle and plasticity index. The sensitivity of the normal operating slope stability analysis to cohesion is discussed below.

Material Properties

Table 4-1 below provides a summary of soil material properties used in the analysis. The embankment stratigraphy, natural ground surface elevation, and geometry were determined based on field measurements, existing drawings, and logged boring data.

TABLE 4-1
SUMMARY OF MATERIAL PROPERTIES USED IN ANALYSIS

Material Types	γ_{moist} (pcf)	γ_{sat} (pcf)	c' (psf)	φ' (degrees)	$d_{Kc=1}$ (psf)	$\psi_{Kc=1}$ (degrees)
Native Soil	N/A	130	0	30.0	1,000	0
Clay Liner	130	130	0	30.0	1,000	0
Ash Fill (Storage)	N/A	90	0	30.0	N/A	N/A
Embankment Fill	125	135	0	37.0	0	28.7

Rapid Drawdown Material Properties

The required material properties for the rapid drawdown analysis was calculated from the above drained and undrained strength parameters. In addition to the cohesion and friction angle used in most stability analyses, the computer program UTEXAS4 uses the parameters $d_{Kc,}$ and $\psi_{Kc.}$ These parameters describe the relation between the shear strength and effective consolidation stress on the failure plane according to a linear relation, with two parameters: d (intercept) and ψ (slope angle), for two states of isotropic consolidation - $K_c = 1$ developed from the Consolidated Undrained (CU) triaxial test and conventional effective strength parameters, $K_c = K_f$.

1. Fill material second stage: $d_{Kc=1} = 0$, $\psi_{Kc=1} = 28.7°$, $d_{Kc=Kf} = 0$, $\psi_{Kc=Kf} = 37°$
2. Natural soil / Clay liner second stage: $d_{Kc=1}$ = 1,000 psf, $\psi_{Kc=1} = 0°$, $d_{Kc=Kf} = 0$, $\psi_{Kc=Kf} = 30°$

Note that UTEXAS4 selects the lower of the input undrained and drained strengths for each section of the failure arc, in accordance with the recommended procedure. From the output, it is not apparent which drainage condition governed, although it was determined that the undrained failure condition provides the lowest factor of safety.

It was further assumed that the ash fill acts as a soil, and that the strength of the ash fill would not influence the analysis of the downstream slope. The failure surface was limited to the top of rock elevation.

Discussion of Rapid Drawdown Analysis

Flooding of the Susquehanna River can create a rapid drawdown condition on the downstream slopes of the ash basin embankments, which is an unusual loading condition. Drawdown analyses are typically conducted for the upstream face of the embankment in reservoirs, such as pumped storage projects, where rapid, large magnitude fluctuations of reservoir level can occur. For upstream analyses, the seepage gradient is the opposite of the normal direction of seepage, as drainage is relieved at the upstream face. Upstream drawdown failures do not result in a breach of the embankment, as the triggering mechanism is the withdrawal of water from the reservoir. For rapid drawdown at the downstream face, the normal seepage and drawdown seepage gradients act in the same direction, which is likely a more severe condition. There are no clear criteria for this analysis.

For a slope failure related to rapid drawdown to occur, the embankment must be partially or completely saturated at the higher level and must drain slower than the tailwater recedes. The embankment saturation is a function of several factors. The steady state saturation level in the east embankment appears to be high, at least as it appeared in spring 2008. Significant flooding in the Susquehanna will likely occur in the spring when groundwater levels tend to be higher, and will be accompanied by heavy rains, further raising the saturation level in the embankment. The same is true for a tropical storm-related flood, which is the likely severe flood scenario. However, the rising limb of the hydrograph is steep (approximately two days during Hurricane Agnes), and the falling limb is somewhat shallower (4 days during Hurricane Agnes). Therefore, it seems unlikely that significant saturation will occur that cannot drain. This was addressed in part by back calculating strength parameters for conditions where shallow failures were observed to occur, using the same methodology for the analysis of the higher level, but this method becomes less applicable with deeper failure surfaces that would be slower to saturate.

USACE EM 1110-2-1902 discusses a detailed procedure to evaluate the strength parameters to be used for the rapid drawdown analysis. This rationale is based in part on the assumption that shear strength properties are governed by consolidation conditions, and in part on the assumption that significant laboratory testing data would be available, allowing discrimination between rapid and slow strength testing results. This embankment is relatively low, and we are assuming that foundation soils are pre-consolidated due to past desiccation, while embankment soils are pre-consolidated due to compactive effort. An analysis of the embankment susceptibility to erosion from high flood flows was not conducted as part of this stability analysis. PPL reported that a scour study was conducted in 2007 which concluded scour would not be a problem as a result of low shoreline velocities.

As observed in the piezometer data, the piezometers at Sta 7+44 show the phreatic surface below the bottom of the piezometers, while the ground surface is still wet. The majority of the borings show sand layers in the foundation underlying the embankment. The continuity of this sand layer and its effect on drainage is not known, but it is apparent that the effect is not uniform, as evidenced by the differences between the two sections.

Section 5

Analysis Results and Conclusions

5.1 Discussion

Slope stability analyses of Section 1-1 were conducted using limit equilibrium methods and the properties shown in Table 4-1 for normal, surcharge, rapid drawdown, and seismic loading conditions as described in Section 4.0. The slope stability software UTEXAS4 was utilized for the analyses. EM 1110-2-1902 recommends that slope stability analyses be checked, either by hand or using an independent slope stability program, with the work done by an independent analyst. The factors of safety for each condition were independently verified by a second engineer with the slope stability program, SLOPE/W. To check the accuracy of the developed model and assumed parameters, the rapid drawdown associated with the highest flood of record, having occurred in 2004, was analyzed first. Consistent with previous field observations of shallow sloughs, the result exhibited a factor of safety less than 1.0 for a circular failure surface of approximately 3-foot depth.

Typically, the minimum factor of safety will correspond to a shallow failure surface. While a shallow failure will result in some slope movement and loss of vegetation, it is unlikely to result in a breaching failure of the embankment and the loss of the reservoir. However, shallow failures can be a recurring maintenance issue and concern to inspectors. The software used was directed to identify both shallow and deep failure surfaces.

Analysis summary diagrams for each loading case are provided in Appendix E. Table 5-1 below also summarizes the results of the analyses conducted for all loading cases to identify deep failure surfaces.

A critical failure surface was defined as a failure surface that extended deep enough into the embankment that it intersected the crest.

As shown in Table 5-1, the factor of safety against sliding is acceptable under the 10-year-flood and earthquake loading conditions. Based on these results, it is unlikely that a significant slope failure will occur for these conditions, although shallow failure surfaces without the potential to reach the embankment can be expected. Note that prompt repair of these slope failures is necessary, as these areas are more vulnerable to future slope movement than the surrounding slopes.

Rapid drawdown loading for both the 100-year flood and the 500-year flood levels was determined to be the most critical loading condition. For both flood levels, the factor of safety is less than what is required by the acceptance criteria discussed in Section 4.0. It is noted that the failure surface for these flood levels is entirely within the embankment section; and therefore, the foundation strength assumptions will not affect the results.

The factor of safety for the pseudostatic seismic analysis of 1.2 is acceptable. The calculated yield acceleration necessary to initiate noticeable permanent crest displacement was calculated as 0.14g, which is considerably higher than the seismic coefficient of 0.06g determined to be appropriate. Minimal deformation is anticipated, as expected for a low, well-compacted embankment in a low to moderate seismic region.

TABLE 5-1
SUMMARY OF STABILITY ANALYSES RESULTS

Loading Condition	Factor of Safety Against Deep Failure[1]	Required Minimum Factor of Safety	Factor of Safety Against Shallow Failure[4]	Sensitivity Factors	Notes
Normal	1.41	1.5	N/A[3]	Foundation material cohesion	Although sand and gravel was encountered in most borings, a small amount of cohesion effective for the composite foundation could exist.
Surcharge	1.31	1.4	N/A[3]	Foundation material cohesion	Although sand and gravel was encountered in most borings, a small amount of cohesion effective for the composite foundation could exist.
10-year Flood	1.14	1.1	1.00	Embankment cohesion	Due to variable nature of fill and results of lab test data, assumption of cohesion for embankment material is not reasonably conservative.
100-year Flood	1.0	1.1	0.83	Embankment cohesion; Initial embankment phreatic surface	Assuming a lower phreatic surface does not affect the phreatic surface in the failure zone during the flood condition
500-year Flood	1.0[2]	1.1	0.76	None	The failure surface extends to upstream edge of the embankment crests.
Earthquake	1.2	1.2	N/A[3]	Increased seismic coefficient	The yield acceleration is higher than PGA for reasonable PGA values.

1 Factor of safety is the minimum for a failure surface passing through the embankment crest.
2 For very deep failure surface that encompasses entire width of crest; all other failure surfaces have FS < 1.0.
3 No surficial failure surfaces were identified for normal, surcharge and earthquake loading conditions, as the slope surface was not modeled as saturated during these conditions.
4 Failure surface is approximately 3 feet deep. Shallower surfaces will have lower factors of safety.

5.2 Sensitivity Analysis

Sensitivity analyses were performed by varying the parameters shown in Table 5-1, as well as the reservoir water levels. The results of the sensitivity analyses are discussed below.

Normal and Surcharge Loading Conditions

Without altering the embankment fill strength parameters, a relatively small cohesion value of 45 psf was assumed for the foundation (native) soil material. The assumed foundation material strength is summarized in Table 5-2 below.

TABLE 5-2
PROPERTIES USED IN FOUNDATION COHESION SENSITIVITY ANALYSIS

Material Type	γ_{moist} (pcf)	γ_{sat} (pcf)	c' (psf)	ϕ' (degrees)
Foundation (Native)	N/A	130	45	30.0

The stability analysis diagram is provided in Appendix E. Table 5-3 below presents the results of this sensitivity analysis.

TABLE 5-3
RESULTS OF FOUNDATION COHESION SENSITIVITY ANALYSIS

Loading Condition	Factor of Safety[1] Without Cohesion	Factor of Safety[1] With 45 psf cohesion	Required Minimum Factor of Safety
Normal	1.41	1.51	1.5
Surcharge	1.31	1.40	1.4

1 Factor of safety is for a failure surface passing through the downstream edge of the embankment crest.

Although the sand lenses in the foundation indicate that reliance on significant cohesion is not appropriate, the analysis does indicate that a very small amount of cohesion would increase the factors of safety for the normal and surcharge conditions above the recommended minimums. As noted above, foundation cohesion would not affect the rapid drawdown analysis, as the critical failure surface is confined to the embankment.

Rapid Drawdown Loading Condition

The sensitivity of the embankment slope stability analysis for the 2004 flood (referred to as the 10-year flood) and the 500-year flood was assessed by changing the strength parameters of the embankment fill, and by changing the upstream water levels. Cases with embankment strengths lower and higher than the base case were assumed. The assumed embankment strength for these two cases is presented in Table 5-4 below. The stability analysis diagram is provided in Appendix E.

TABLE 5-4
ASSUMED EMBANKMENT FILL STRENGTHS FOR SENSITIVITY ANALYSIS

Embankment Fill Strength	γ_{moist} (pcf)	γ_{sat} (pcf)	c' (psf)	ϕ' (degrees)	$d_{Kc=1}$ (psf)	$\psi_{Kc=1}$ (degrees)
Low strength	125	135	0	34.0	0	27.0
Original strength	125	135	0	37.0	0	28.7
High strength	125	135	0	37.0	288	28.0

A summary of the calculated factors of safety resulting from altered embankment fill strength is provided in Table 5-5 below.

TABLE 5-5
RESULTS OF EMBANKMENT FILL STRENGTH ON RAPID DRAWDOWN ANALYSIS

Loading Case, Assumed Strength	Factor of Safety[1] Base Case	Factor of Safety[1] Low Strength Fill	Factor of Safety[1] High Strength Fill	Required Minimum Factor of Safety
10 year flood	1.14	1.1	1.44	1.1
100 year flood	1.0	0.91	1.27	1.1
500 year flood	<1.0	0.80	1.20	1.1

[1] Factor of safety is for a failure surface passing through the downstream edge of the embankment crest.

Change in Embankment Phreatic Level

The embankment phreatic level in the analysis for flood (rapid drawdown) conditions is influenced by the initial phreatic surface, the rate of rise and fall of the tailwater flood elevation, and the permeability of the embankment material. Since the failure surface associated with the 100-year flood is shallow yet passes through the crest of the embankment, as shown in Appendix E, an initial phreatic surface lower than what is assumed in the analysis will not effect the analyses or improve the factor of safety. A higher phreatic surface through the embankment was analyzed to quantify its effects, and the corresponding stability analysis diagram is provided in

Appendix E. It can be observed that the factor of safety is reduced from 1.0 to 0.91 with the higher assumed phreatic surface. Reducing the reservoir level for the 500-year flood does not impact the factor of safety, since the tailwater is close to the crest and almost the entire embankment is assumed to be saturated.

5.3 Analysis Summary

For the normal and surcharge loading condition, the stability of the embankment was slightly below recommended values, but is considered satisfactory. As noted in COE Manual EM 1110-2-1902, “Acceptable values of factors of safety for existing dams may be less than those for design of new dams, considering the benefits of being able to observe the actual performance of the embankment over a period of time.” No significant seismic deformation is anticipated. For the rapid drawdown condition, for a return period of as short as 100 years, the embankment does not meet the required factor of safety of 1.1 for a failure surface that passes through the embankment crest. Following a rapid drawdown failure, progressive slope failures may continue for embankment sections below the phreatic surface that have lost support from the displaced soil mass. The possibility that this could lead to a breach of the embankment cannot be discounted. This condition is considerably more severe under 500-year flood drawdown conditions.

There are several factors that lead to a recommendation that the embankment be remediated for the drawdown condition. The calculated factor of safety using current recommended practice is deficient, and there is evidence of shallow slope failures at several locations that resulted from a nominal flood. The Susquehanna River has a very large basin with minimal regulation, so that significant flooding can be expected in the future. The ash basin is essentially a permanent structure, and it is likely that the moisture content of the ash and its ability to flow when unconfined will not change in the foreseeable future. A breach of the ash basin and an uncontrolled discharge of a large quantity of ash into the Susquehanna River would have major ecological and economic impacts. Assuming a major failure does not occur, sloughing could be expected during major flood events. Approximately 300 feet of the embankment has suffered slides thus far, as a result of exposure to roughly 10-year-flood events. Significantly greater sloughing can be anticipated in the future unless steps are taken to prevent it. The factor of safety for shallow slope failures drops from 1.00 for the 10-year flood to 0.83 for the 100-year flood to 0.76 for the 500-year flood, indicating that significant damage can be expected, even if the embankment does not fail.

Conversely, it is likely that the assumption of complete saturation without drainage is highly conservative. Because these simplifications tend to be conservative, a relatively low factor of safety is considered acceptable, with a value of between 1.1 and 1.3 recommended by the Corps of Engineers for dams, and 1.0 considered acceptable for levees. The 1.1 factor of safety corresponds to an embankment subject to drawdown from flood levels above the normal water level, which corresponds most closely to this case. A transient analysis would be required to model the likely degree of saturation, and this would require quantification of a number of variables, including the permeability of the random fill, the impact of foundation sands which underlie portions of the embankment, the method of closure of the ash basin, saturation resulting from conditions precedent to the design flood, and the timing of the both the rising and falling limbs of the design flood. There are plausible scenarios however, such as the back to back flood events in 1955 which is the flood of record for much of the northeast, where saturation is conceivable. As noted in EM 1110-2-1902, transient analyses are generally considered to be beyond the current state of the art, but in this case could be warranted.

The sensitivity analyses indicated that a relatively small cohesion of 288 psf (2 psi) would provide an adequate factor of safety for the 500-year flood condition. While the use of this cohesion is not supported by the one triaxial test conducted, additional testing could justify the use of cohesion at other sections.

Lowering the phreatic surface within the reservoir and embankment does not significantly affect the results of the analyses for either the 100- or 500-year floods. This is seen in pages E20 through E23 of the sensitivity analysis. This is due in part to the analysis assumptions, and it is likely that lowering the reservoir water level would improve actual drawdown stability, although this could only be quantified by a transient analysis. Lowering of the reservoir level should be considered for significant river floods until the embankment is remediated or has been determined to be adequate for drawdown by additional analyses.

The stability of the embankment slope of the polishing pond is anticipated to be essentially the same as the rest of the embankment; however, a significantly deeper failure surface can be tolerated without the potential for a release of ash.

Section 6
Recommendations

We recommend that PPL improve the stability of the embankment for the rapid drawdown condition, or that additional transient analyses be conducted to better define the drawdown saturation assumptions.

We have identified the following stabilization alternatives:

- The most common means of stabilizing an embankment for drawdown is through the construction of a free-draining stabilization berm or shell. A filter could also be incorporated to address the unfiltered seepage observed at the site. The berm or shell would likely be needed on the east, south, and west slopes, although this should be verified through analysis of each of these areas. Construction of a berm or shell will entail significant cost.
- After the ash basin is closed, it may be possible to seal or cap the downstream slope to prevent saturation during river flooding. The design and analysis of a capping system would be complicated, as there needs to be a continuing provision for ash drainage, and portions of the embankment foundation appear to be permeable sands that would be hydraulically connected to tailwater. This option would need to be evaluated in more detail before its viability can be confirmed.
- Lowering the reservoir alone, or in combination with a slurry cut-off wall, does not significantly improve the stability with respect to steady state analyses, although it likely would have a significant beneficial effect in a transient analysis. A slurry wall would create the potential for a weakened plane that would need to be considered.

Until a final stabilization plan is implemented, PPL should consider the following:

- Repair the existing sloughed areas;
- Drawdown the reservoir if significant tailwater flooding is forecast. While this is not expected to have a major effect, it may reduce the likelihood of progressive failure; and
- Continue periodically monitoring piezometers until annual trends can be established.

HDR|DTA

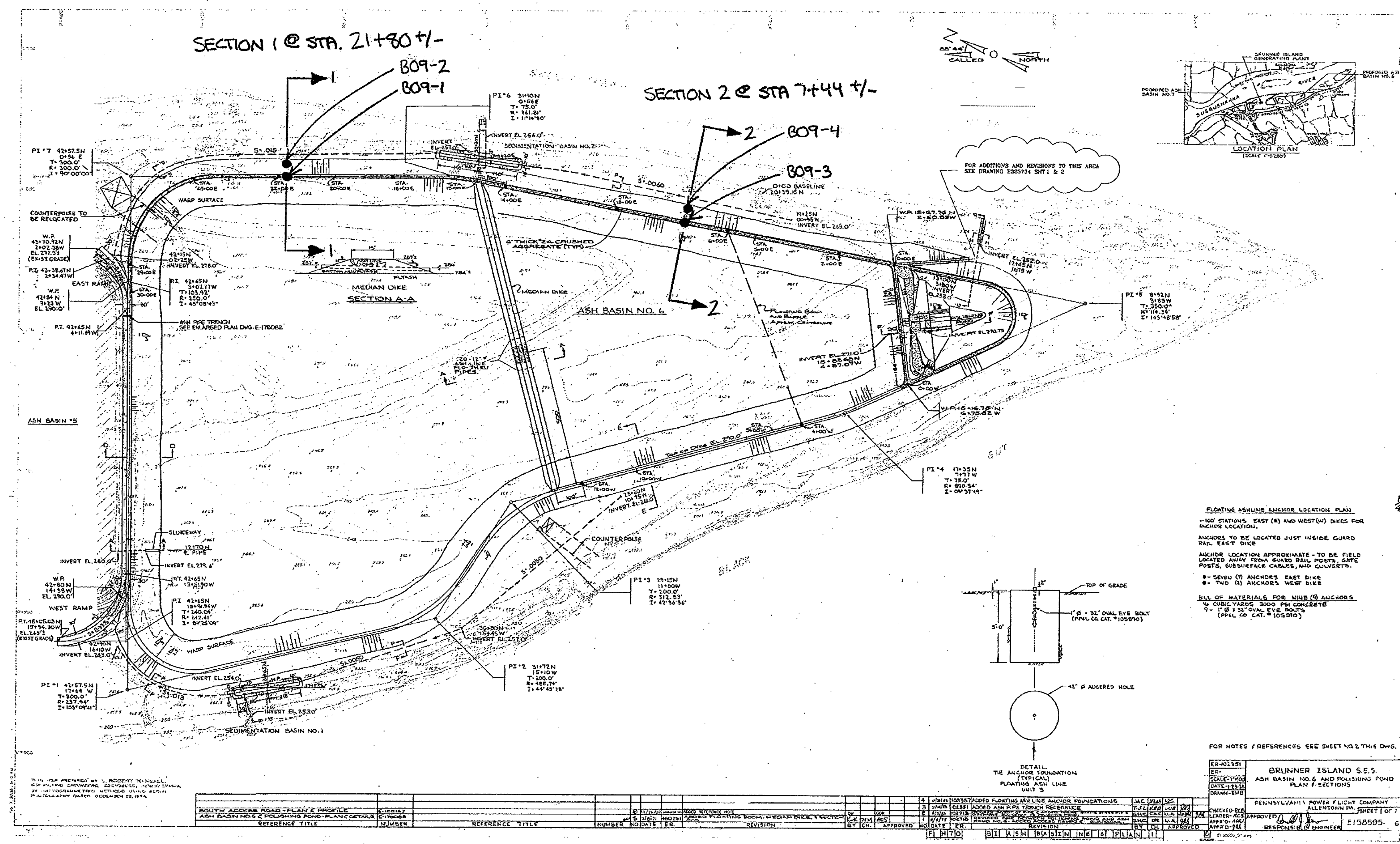
Adam N. Jones
Project Engineer

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
ADAM JONES
ENGINEER
No.PE075739

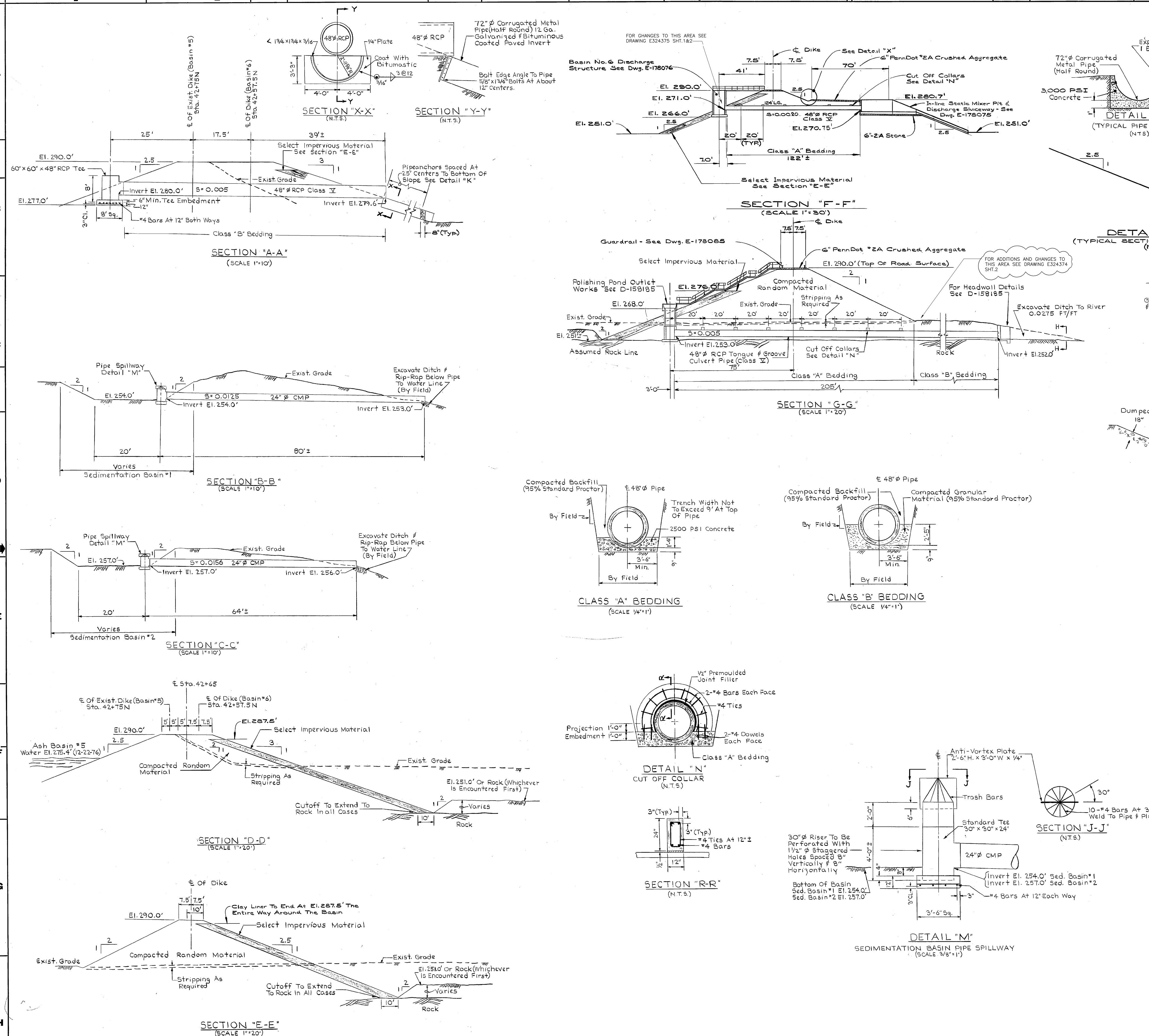
12/16/09

P:\PPL_PA\106864\WordProcessing\Reports\Brunner Island Stability Report\Brunner 6 Stability Rpt-091216.doc
ANJ//JKR
December 16, 2009

APPENDIX A
PROJECT DRAWINGS



PPL/BRUNNER ISLAND
GEOTECHNICAL EXPLORATION
BORING PLAN (REVISED)
5/28/09



NOTES:

For specifications, see specification PPC-1333, "Earthwork".

All coordinates are based on North-South and East-West base lines of plant.

Entire outside slope of embankment and inside slopes above elevation 274.0' in Basin #6 and above elevation 268.0' in polishing pond shall be topsoiled and seeded as per spec's.

Interceptor channels by field except as noted.

Topography obtained by photogrammetric methods using aerial photography dated December 22, 1976.

All inside slopes of basin #6 and polishing pond shall be lined with a 10 ft. wide blanket of impervious material extending to rock.

ESTIMATED QUANTITIES

Clearing and Grubbing – 69 Acres
Stripping Topsoil (1.0') – 111,000 Cu. Yd's
Common Excavation – 1,839,000 Cu. Yd's
Random Fill – 566,000 Cu. Yd's
Impervious Fill – 115,000 Cu. Yd's
#2A Crushed Aggregate – 1,550 Cu. Yd's
Guardrail – 8,300 Lineal Feet

REFERENCE TITLE	NUMBER	REFERENCE TITLE	NUMBER
ASH STORAGE AREAS #4 & #5 - PLAN	LF-75333		
ASH BASIN #6 & POLISHING POND - OUTLET WORKS & HEADWALL	D-158185		
ASH BASIN #7 - PLAN & SECTIONS	E-157640		
ASH BASIN #6 - LOCATION & LOG OF CORE DRILL HOLES	D-129687	BILL OF MATERIAL	A-159148

NO.	DATE	ER.	REVISION	BY	CH.	APPROVED
4	11/26/07		ADDED REFERENCE NOTE TO SECTION G-G	DM		GDH
3	11/20/06		ADDED NOTE TO SECTION F-F	DM		GDH

NO.	DATE	ER.	REVISION	BY	CH.	APPROVED
2	4/2/80	102713	ADDED IN-LINE STATIC MIXER PIT, DISCHARGE SLUICEWAY, REVISED INV. & LENGTH OF 48"Ø R.C.P. IN SECT. "F-F", DELETED DETAIL "Y".	G.H.C.	FAC	A.L.M. WJB JAS JAS
1	6/8/79	102713	REVISED DETAIL "K" AND ADDED DETAIL "Y".	G.H.C.	DPK	A.L.M. JAS
			ADDED GUARD RAIL & AGGREGATE QUANTITIES & DET. "X".			
			REVISED SECT. "F-F" & CLAY IN SECT. "D-D", "E-E", & "G-G".			

LOC CODE: F H 7 0 — DESCRIPTION: BI ASH BASIN NØ 6 PLAN 2 — SORT: C

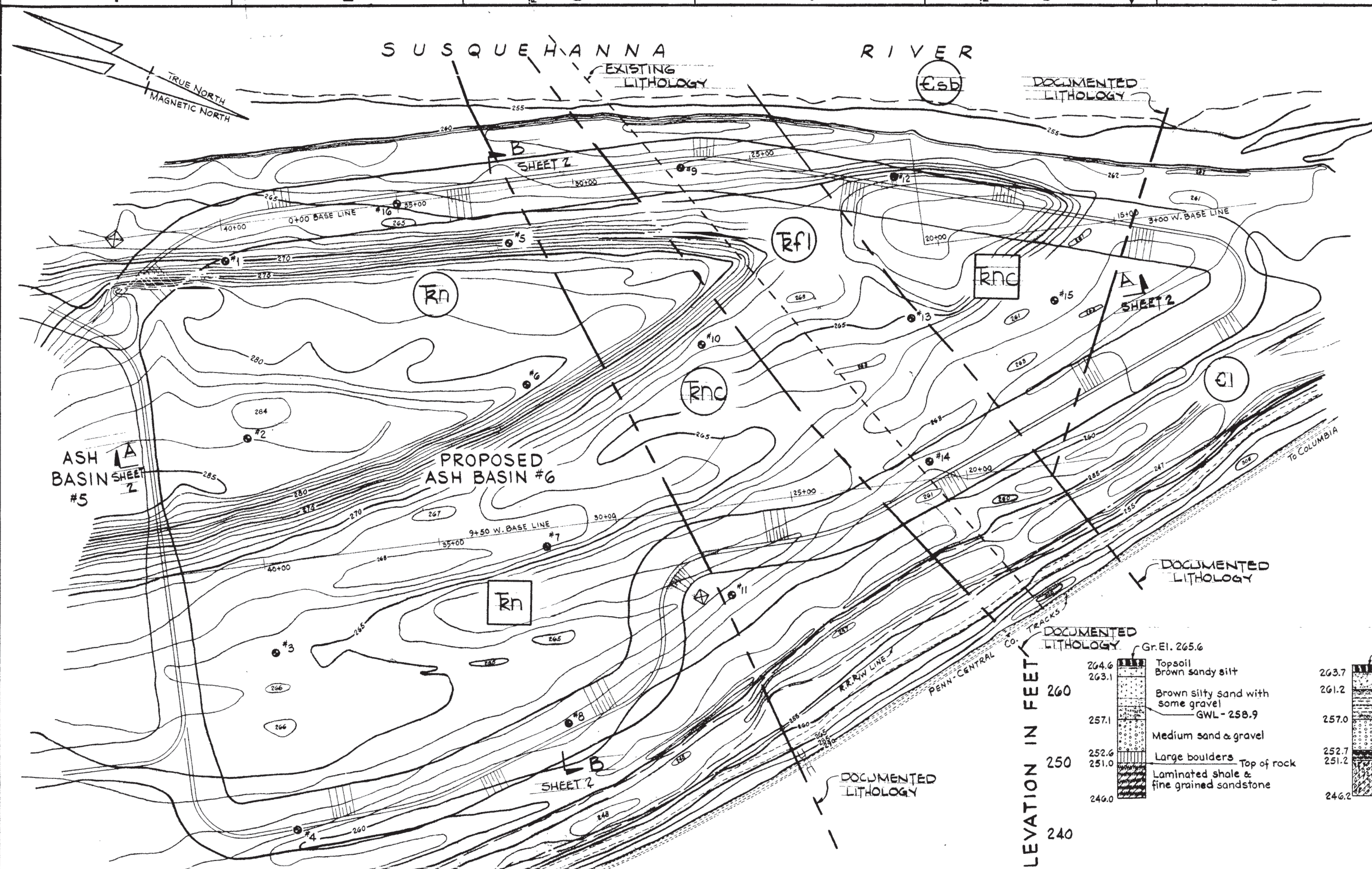
ER- 102351
ER-
SCALE- AS NOTED
DATE- 1-23-78
DRAWN- EMB
CHECKED- RCB
LEADER- RCS
APPR'D- NHJ
APPR'D- JAS

BRUNNER ISLAND S.E.S.
ASH BASIN NO. 6 AND POLISHING POND PLAN & SECTIONS

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA. SHEET 2 OF 2
RESPONSIBLE ENGINEER
E158595-4

E158595_S2.dwg

FRACTIONAL SCALE — DECIMAL SCALE



BORING LOCATION PLAN

SCALE: 1" = 200'

GEOLOGY KEY

Ꞧn NEW OXFORD FORMATION

Ꞧnc NEW OXFORD CONGLOMERATE

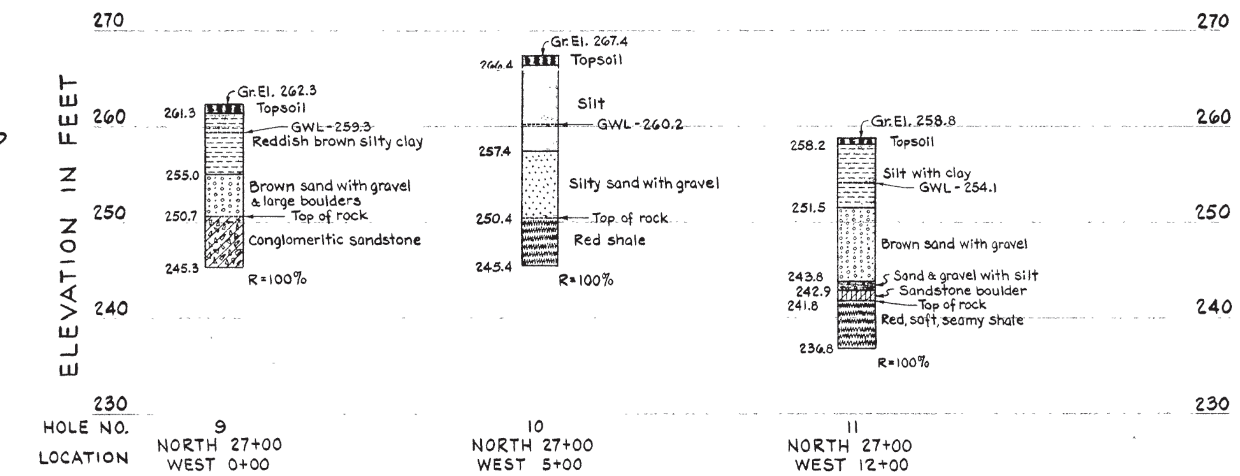
Ꞧfl LIMESTONE FANGLOMERATE

Єsb SNITZ CREEK & BUFFALO SPRINGS FORMATIONS, UNDIV.

Єl LEDGER FORMATION

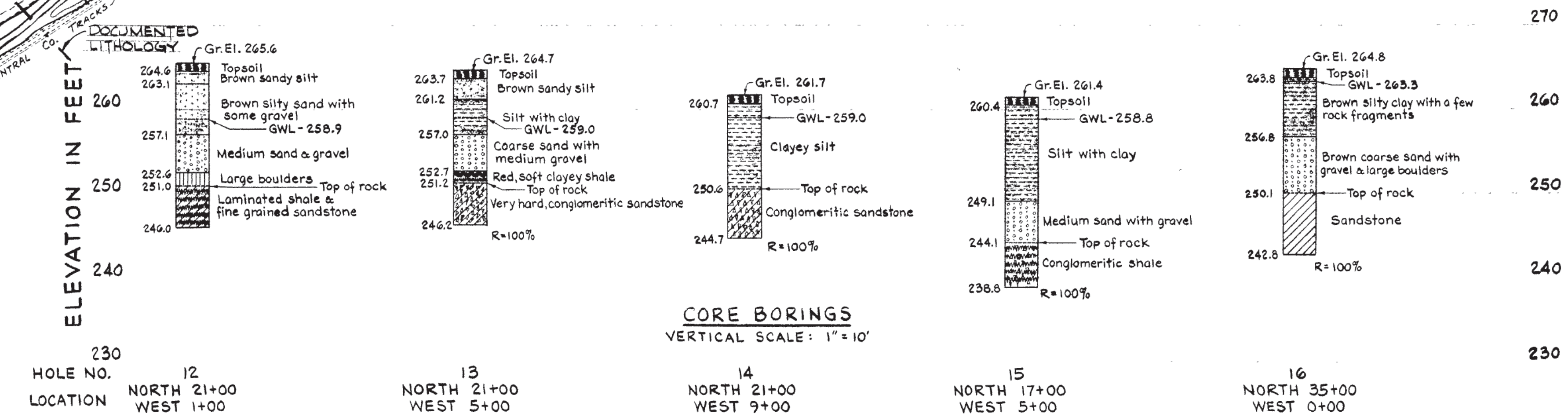
◯ DENOTES DOCUMENTED LITHOLOGY

▢ DENOTES EXISTING LITHOLOGY (BASED ON BORING LOGS)



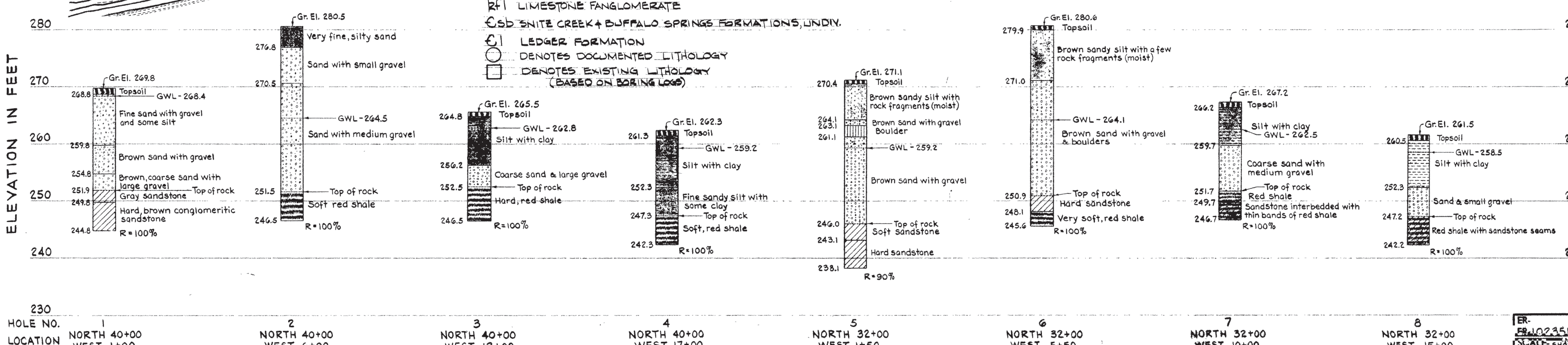
NOTES

All ground elevations are original ground elevations.
The ground water elevations were determined during the period from February 25, 1975 to March 17, 1975.
R = Percent of core recovered from last 5' of rock.
GWL = Ground Water Level
Drill holes are shown as ⊗
Gr.El. = Elevations in feet of the top of the bore hole.



CORE BORINGS

VERTICAL SCALE: 1" = 10'



LEGEND

SILT	SHALE
SAND	CONGLOMERATE
GRAVEL	SANDSTONE
CLAY	TOPSOIL
BOULDER	

REFERENCE TITLE	NUMBER
BRUNNER ISLAND ASH STORAGE AREAS #4 & #5	LF-75333
BRUNNER ISLAND TOPOGRAPHY & CONTOURS	LG-46437

NO.	DATE	ER.	REVISION	CH.	BY	APPROVED
1	7-27-76	107146	ADDED SECT A-A + B-B (MARKS), SHT 2, EXIST & DOCUMENTED GEOLOGY	JTE	MS	

ER-FR-102351
SCALE-SHOWN
DATE-7-3-75
DRAWN-M.B.W.
CHECKED-RCB
LEADER-FHW
APPR'D.MSG
APPR'D.

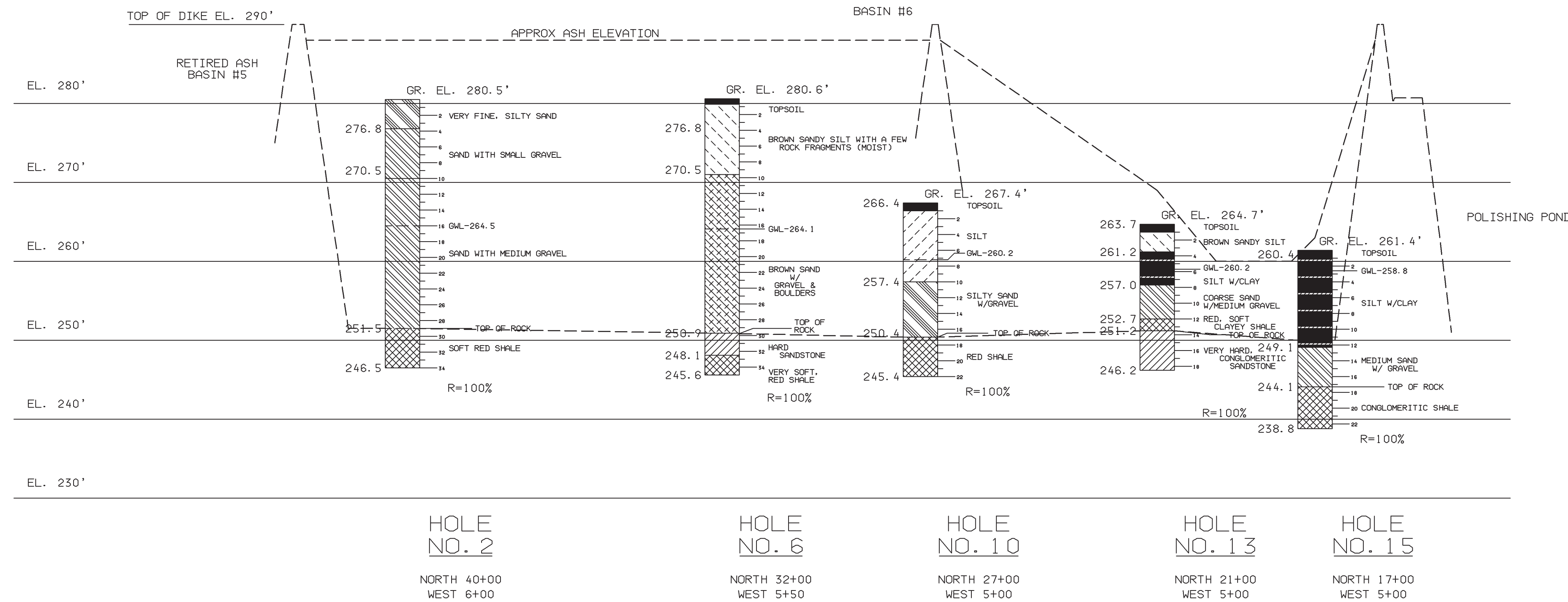
BRUNNER ISLAND S.E.S.
ASH STORAGE BASIN #6
LOCATION AND LOG OF CORE DRILL HOLES
EAST MANCHESTER TWP., YORK CO., PA.

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA.

SHEET 1

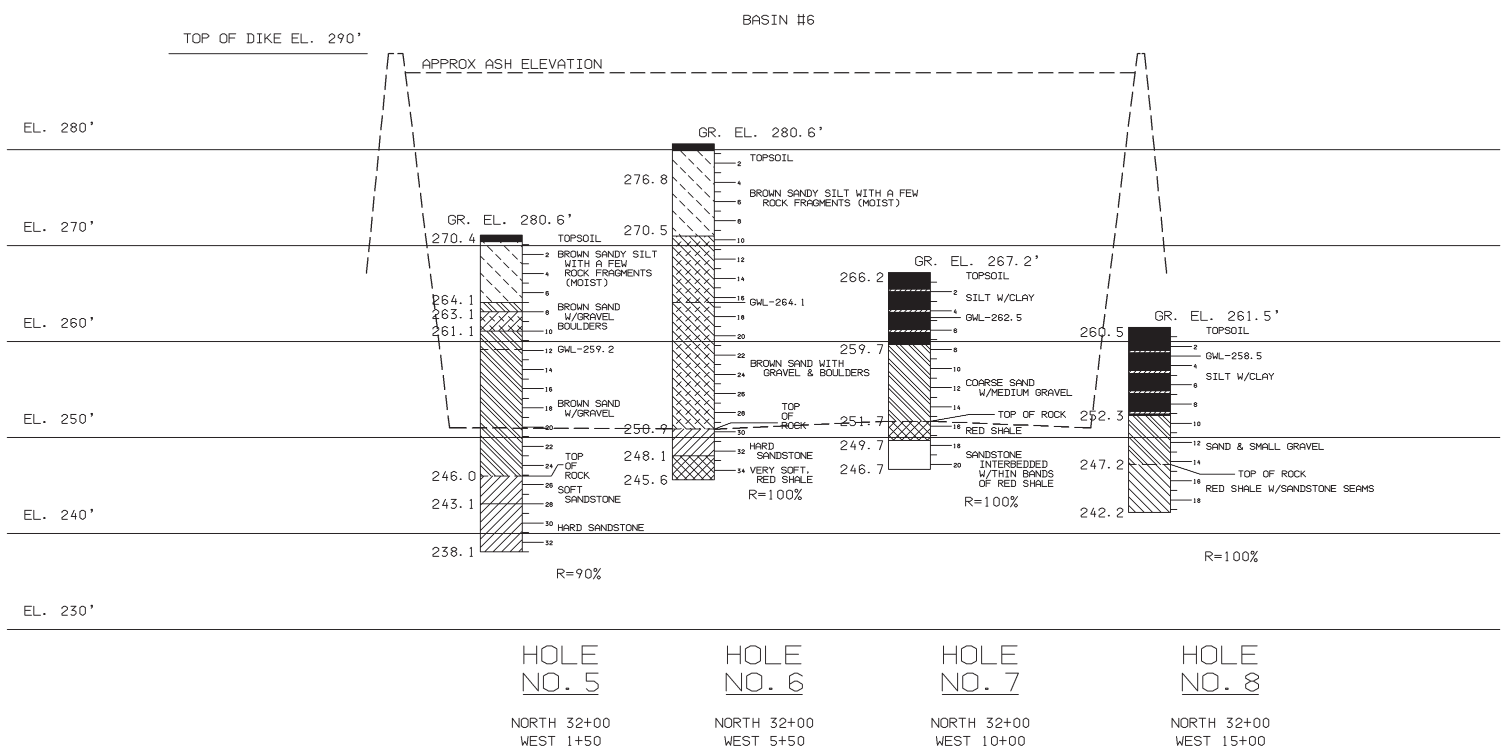
APPROVED
SPONSOR ENGINEER

D-129687-1



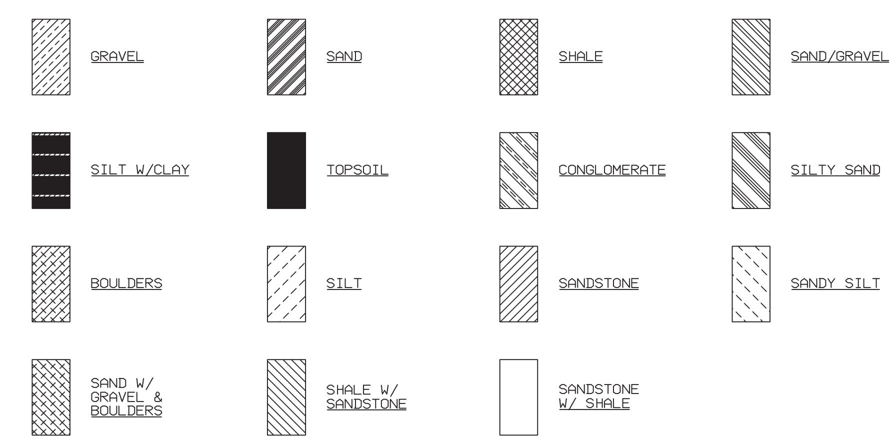
SECTION A-A

SCALE:
HORIZONTAL 1"=200'
VERTICAL 1"=10'



SECTION B-B

SCALE:
HORIZONTAL 1"=200'
VERTICAL 1"=10'



LEGEND

102146
AS SHOWN
JTE

BRUNNER ISLAND S.E.S.
ASH BASIN NO. 6
LOG OF CORE DRILLING HOLES
SECTIONS A-A AND B-B

A.D. SPEAR 3/31/96

D129687 2 0

APPENDIX B
SITE PHOTOS

Photo 1 – Wet area at toe of the East Embankment, looking north from Sta 0+30. (2009 annual inspection)

Photo 2 – Slope sloughing in the East Embankment, looking north from Sta 22+10. (2009 annual inspection)

Photo 3 – Slope slough near the north end of the West Embankment.

Photo 4 – Advancement of Borehole B09-1 at Sta 21+80 using truck-mounted drill rig.

Photo 5 – Two piezometers installed at Borehole B09-3 with different screen intervals.

Photo 6 – View of typical trench dug for installation of drain pipe from piezometer cover.

Photo 7 – Crest boring and piezometer cover marked to avoid disturbance during later work at the site. Note the removal of the guardrail cable for downslope access.

Photo 8 – Typical placement of skid-mounted drill rig at downslope borings.

Photo 9 – View of drilling site looking south, adjacent to Sta 21+80.

Photo 10 – Marked piezometer standpipe cover at completed Borehole B09-2.

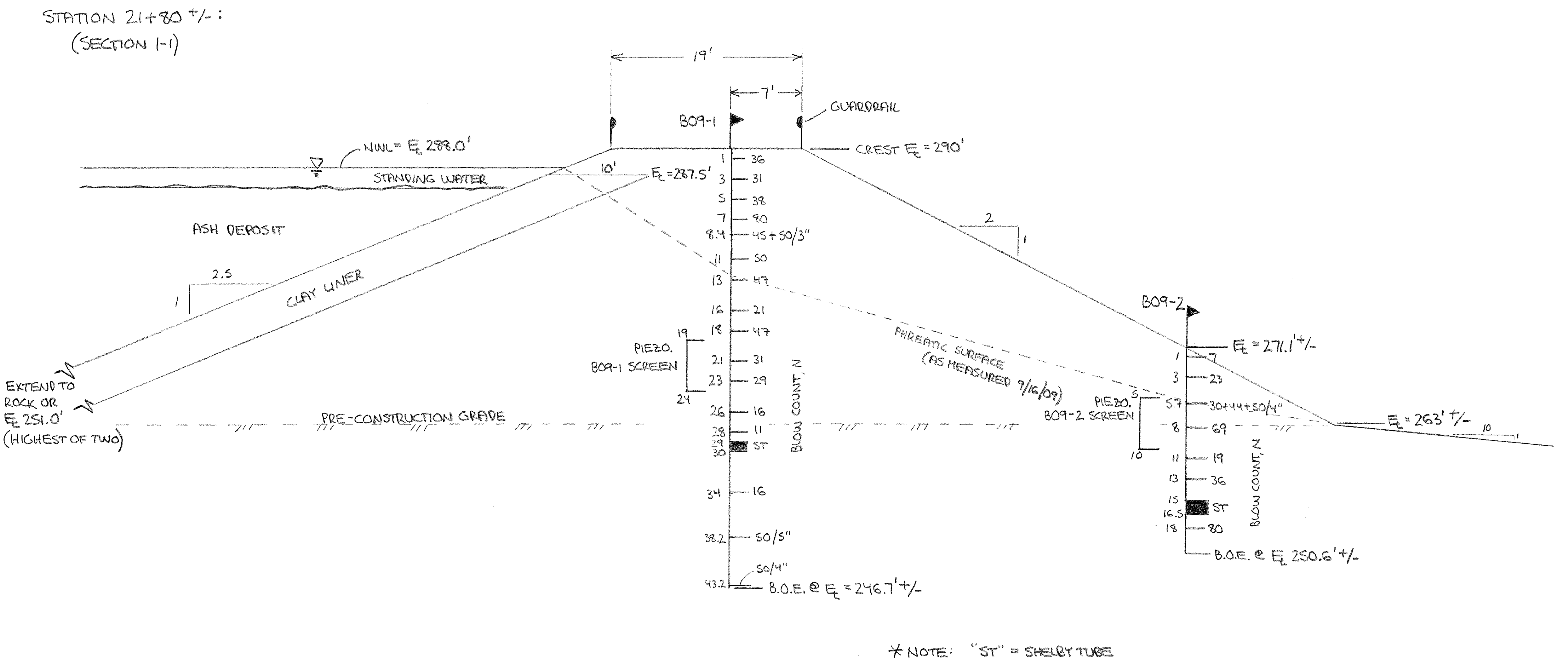
Photo 11 – Wet ground surface conditions during drilling of Boring B09-4, especially evident after digging of bench area.

Photo 12 – Split-spoon sample taken near top of natural soil in Boring B09-3, consisting of very stiff silty clay.

Photo 13 – Split-spoon sample of foundation soil from Boring B09-3, consisting of dense silty sand with gravel.

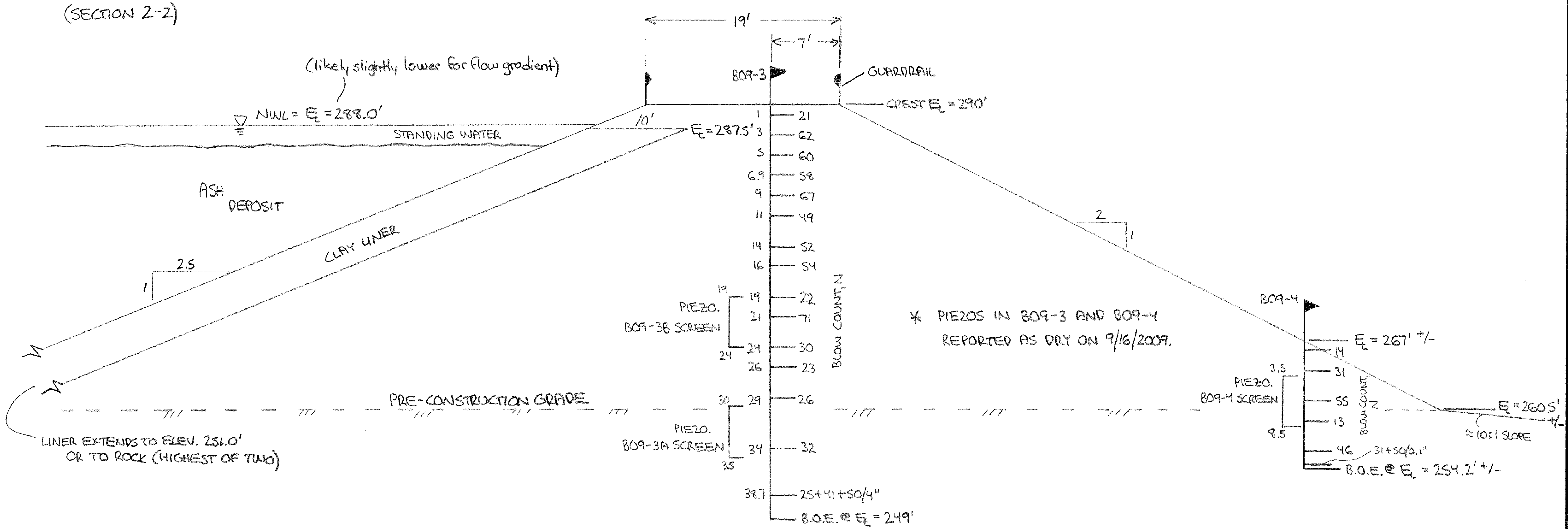
Photo 14 – Split-spoon sample of embankment fill material from Boring B09-1, consisting of gravelly silt with fine to coarse sand.

APPENDIX C
CROSS-SECTIONS, BORING LOGS, & PIEZOMETER DETAILS



REV	BY	DATE	CHECKED	DATE	BRUNNER ISLAND AB 6 - STATION 21+80	
	NBS	9/23/09			JOB NO / CALC NO	PAGE 1 OF 2

STATION 7+44 +/- :
(SECTION 2-2)



						JOB NO	PAGE 2
	NBS	9/23/09				CALC NO	OF 2
REV	BY	DATE	CHECKED	DATE			

HDR

Client: PPL Allentown, PA	Project : Brunner Island Ash Basin #6 Geotechnical Exploration Project Location: York Haven, PA Project Number: 106864	Boring: **B09-1** Sheet: **1 of 2** Location: Sta. 21+80 - Crest Coordinates: , Ground Surface Elevation: ± 290 ft. MSL Datum:

Boring Contractor:	CGC Geoservices
Boring Foreman:	Dan Bowles
Drilling Method:	4-1/4" HSA/SPT
Core Barrel:	N/A
Drilling Equipment:	Acker Soilmax
Boring Logged By:	BRR
Dates Started: 6/10/09	Finished: 6/10/09

Water Level Observations

	Date	Time	Casing (ft)	Water (ft)	Caved (ft)
Completion (Borehole)	6/10/09	4:50 pm	43.3	39.4	
Completion (Piezometer)	6/11/09	1:00 pm		12.6	
24 to 72 Hours	6/12/09	9:00 am		11.8	
Extended Reading	6/15/09	7:30 am		12.3	
Extended Reading	6/18/09	7:45 am		12.5	

Depth & Elevation (Feet)	Sampling Type	Sample Name	Data	Rec. (in.)	Material Description & Classification	Lithology	PL / MC / LL; N-Value, blows/ft (0 50 100)	Laboratory Tests & Comments	Well
	SS	1 - SS	41+19+17+24 N=36	20"	AGGREGATE BASE COURSE (6 inch) : Silty Sand, fine to coarse, contains gravel **FILL** : Gravelly Silt with Sand, hard, brown, contains zones of silty clay (Qp = 4.5+ tsf)			Soil classifications based on Visual-Manual Procedure in general accordance with ASTM D 2488	
	SS	2 - SS	20+15+16+28 N=31	19"	**FILL** : Silty Clay, hard, brown, contains trace sand and gravel				
5 285.0	SS	3 - SS	12+21+17+12 N=38	18"	**FILL** : Silty Sand with Gravel, dense, brown			Obtained bulk sample #1 from auger cuttings (Approx. depth: 4' - 10')	
	SS	4 - SS	32+42+38+36 N=80	20"	**FILL** : Gravelly Silt with fine to coarse Sand, hard, brown, contains trace clay and zones of silty clay (Qp = 4.0-4.5+ tsf)				
	SS	5 - SS	45+50/3"	8"	Continued:		50/3" >>		
10 280.0	SS	6 - SS	9+23+27+15 N=50	19"	**FILL** : Gravelly Silt with fine to coarse Sand, hard, brown, contains trace clay				
	SS	7 - SS	27+16+31+23 N=47	18"	**FILL** : Silty Clay with Gravel and Sand, hard, brown, contains zones of gravelly silt (Qp = 4.5+ tsf)				
15 275.0	SS	8 - SS	14+11+10+11 N=21	17"	Continued: very stiff, contains zones of gravelly silt and moist silty sand (Qp = 4.0-4.5+ tsf)			Obtained bulk sample #2 from auger cuttings (Approx. depth: 15' - 19') Wet zone at approx. 17'	
	SS	9 - SS	28+23+24+24 N=47	17"	**FILL** : Fine Sandy Silt with Gravel, hard, brown, contains trace of medium to coarse sand and clay			Drilled through cobles and boulders at approx. 19'	
20 270.0	SS	10 - SS	6+12+19+20 N=31	18"	**FILL** : Fine Sandy Silt, medium stiff, brown, contains trace medium to coarse sand **FILL** : Silty Sand with Gravel, dense, brown, moist				
	SS	11 - SS	23+19+10+10 N=29	18"	**FILL** : Silty Sand/Sandy Silt , dense/hard, brown, contains gravel, portions moist to wet **NATURAL SOIL**: Clayey Silt (CL-ML), very stiff, brown to gray brown (Qp = 4.5+ tsf)			Fill/Natural Soil contact approx. at 23'	
25 265.0	SS	12 - SS	12+11+5+4 N=16	18"	**NATURAL SOIL**: Silty Sand/Sandy Silt (SM/ML), medium dense/very stiff, brown, contains coarse sand and gravel with zones of silty clay, portions moist to wet (Qp = 4.0 - 4.5+ tsf)				
	SS	13 - SS	4+5+6+9 N=11	20"	**NATURAL SOIL**: Clayey Silt (CL-ML), stiff, brown to brown gray, contains portions of silty clay and traces of small roots (Qp = 2.0 - 3.0+				
30 260.0	SH	14 - SH		8.5"				Push 3" Shelby Tube 13" (Refusal)	

(Continued)

Notes: 1. SPT performed with automatic safety hammer. 2. Installed 1" diameter piezometer with screening interval approx. from 19' to 24'. 3. Obtained bulk samples from auger cuttings (Approx. depth: 4' - 10' and 15' - 19').

HDR	Project : Brunner Island Ash Basin #6 Geotechnical Exploration
Client: PPL Allentown, PA	Project Location: York Haven, PA
	Project Number: 106864

Boring: **B09-1**

Location: Sta. 21+80 - Crest
Coordinates: ,
Ground Surface Elevation: ± 290 ft. MSL
Datum:

Boring Contractor:		CGC Geoservices
Boring Foreman:		Dan Bowles
Drilling Method:		4-1/4" HSA/SPT
Core Barrel:		N/A
Drilling Equipment:		Acker Soilmax
Boring Logged By:		BRR
Dates	Started: 6/10/09	Finished: 6/10/09

Water Level Observations

	Date	Time	Casing (ft)	Water (ft)	Caved (ft)
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Completion (Piezometer)	6/11/09	1:00 pm		12.6	
24 to 72 Hours	6/12/09	9:00 am		11.8	
Extended Reading	6/15/09	7:30 am		12.3	
Extended Reading	6/18/09	7:45 am		12.5	

Depth & Elevation (Feet)	Sampling: Type	Sampling: Sample Name	Sampling: Data	Sampling: Rec. (in.)	Material Description & Classification	Lithology	PL / MC / LL; N-Value, blows/ft (0 – 50 – 100)	Laboratory Tests & Comments	Well
					tsf, Tor = 0.75 kg/cm2)				
					NATURAL SOIL: Silty Clay (CL), brown, contains trace sand (Qp = 4.0 - 4.5+ tsf, Tor = 0.7-0.9 kg/cm2)*(Continued)*				
35 / 255.0	SS	15 - SS	4+7+9+11 N=16	22"	**NATURAL SOIL**: Silty Clay (CL), very stiff, brown, contains some small roots with softer material near root zones (Qp = 4.0 - 4.5 tsf, Near root zone: Qp = 2.0 tsf)				
	SS	16 - SS	50/5"	5"	**PARTIALLY WEATHERED ROCK (PWR)** Sampled as brown silty fine sand with portions of sandy silt and pieces of brown sandstone, dry		>>		
40 / 250.0									
	SS	17 - SS	50/4"	4"	Continued: Sampled as dark brown mudstone with saturated brown silty fine sand above sample		>>		
					BORING TERMINATED AT 43.3 FEET (SPT Refusal). Safety Hammer used for SPT. Bottom of Boring at 43.3 feet.				

Notes: 1. SPT performed with automatic safety hammer. 2. Installed 1" diameter piezometer with screening interval approx. from 19' to 24'. 3. Obtained bulk samples from auger cuttings (Approx. depth: 4' - 10' and 15' - 19').

Project :	Brunner Island Ash Basin #6 Geotechnical Exploration	Boring:	B09-2
Client: PPL Allentown, PA	Project Location: York Haven, PA	Sheet:	1 of 1
	Project Number: 106864	Location: Sta. 21+80 - Downstream Slope Coordinates: , Ground Surface Elevation: ± 271.1 ft. MSL Datum:	

Boring Contractor: CGC Geoservices
Boring Foreman: Dan Bowles
Drilling Method: ROTARY/SPT
Core Barrel: N/A
Drilling Equipment: Skid
Boring Logged By: BRR
Dates Started: 6/12/09 Finished: 6/16/09

Water Level Observations

	Date	Time	Casing (ft)	Water (ft)	Caved (ft)
Completion (Piezometer)	6/16/09	1:45 pm		3.8	
24 to 72 Hours	6/17/09	9:15 am		5.5	
24 to 72 Hours	6/18/09	7:45 am		5.1	
Extended Reading	6/25/09	9:00 am		5.6	

Depth & Elevation (Feet)	Type	Sample Name	Data	Rec. (in.)	Material Description & Classification	N-Value, blows/ft (PL, MC, LL; 0–50–100)	Laboratory Tests & Comments
	SS	1 - SS	2+2+5+6 N=7	10"	**FILL** : Gravelly Silt with fine to coarse Sand, medium stiff, brown, moist to wet		Soil classifications based on Visual-Manual Procedure in general accordance with ASTM D 2488
	SS	2 - SS	6+11+12+13 N=23	21"	Continued: **FILL** : Fine Sandy Silt, very stiff, brown, dry to moist		
5 266.1	SS	3 - SS	30+44+50/4"	13"	**FILL** : Gravelly Silt with fine to coarse Sand, hard, brown, moist to wet	50/4" >>	Cobbles or gravel at 4.5 ft
	SS	4 - SS	24+42+27+8 N=69	14"	**FILL** : Silty Sand with Gravel, very dense, brown, wet, contains portions of moist to wet gravelly silt with sand		
10 261.1	SS	5 - SS	7+8+11+17 N=19	14"	**NATURAL SOIL**: Silty Clay (CL), very stiff, brown to gray brown, contains portions of clayey silt (Qp = 3.5 tsf)		
	SS	6 - SS	13+16+20+26 N=36	4"	Continued: hard (Qp = 3.0 tsf)		
15 256.1	SH	7 - SH		13"	Continued: contains trace sand (Qp = 3.0-3.5 tsf, Tor = 0.8 kg/cm2)		Set 4" Casing to 15 ft Push 3" Shelby Tube 19" (Refusal)
	SS	8 - SS	10+23+57+50/3" N=80	18"	Continued: hard (Qp = 3.0 tsf) **NATURAL SOIL**: Shale, gray	50/3"	Difficult drilling starting approx. at 18.0'
20 251.1					**PARTIALLY WEATHERED ROCK (PWR)** Sampled as red brown silt with trace sand (Weathered mudstone)		
					TRICONE REFUSAL AT 20.5 FEET. Safety Hammer used for SPT. Bottom of Boring at 20.5 feet.		

Notes: 1. SPT performed with automatic safety hammer. 2. Installed 1" diameter piezometer with screening interval approx. from 5' to 10'.

HDR	Project: Brunner Island Ash Basin #6 Geotechnical Exploration	Boring: **B09-3**
		Sheet: **1 of 2**
Client: PPL Allentown, PA	Project Location: York Haven, PA Project Number: 106864	Location: Sta. 7+44 - Crest Coordinates: , Ground Surface Elevation: ± 290 ft. MSL Datum:

Boring Contractor:	CGC Geoservices
Boring Foreman:	Dan Bowles
Drilling Method:	4-1/4" HSA/SPT
Core Barrel:	N/A
Drilling Equipment:	Acker Soilmax
Boring Logged By:	BRR
Dates Started: 6/8/09	Finished: 6/9/09

Water Level Observations

	Date	Time	Casing (ft)	Water (ft)	Caved (ft)
Borehole - During Drilling	6/9/09	12:30 pm		30.9	
Piezometer B09-3A - 24 to 72 hrs	6/10/09	7:30 am		31.9	
Piezometer B09-3B - 24 to 72 hrs	6/10/09	7:31 am		23.6	
Piezometer B09-3A - Ext. Reading	6/15/09	7:30 am		32.9	
Piezometer B09-3B - Ext. Reading	6/15/09	7:31 am		23.6	

Depth & Elevation (Feet)	Sampling: Type	Sample Name	Data	Rec. (in.)	Material Description & Classification	Lithology	PL / MC / LL; N-Value, blows/ft (0 – 50 – 100)	Laboratory Tests & Comments	Well
	X	1 - SS	16+11+10+17 N=21	20"	AGGREGATE BASE COURSE (4 inch) : Silty Gravel with Sand **FILL** : Silty Clay, very stiff, brown, contains trace gravel and sand (Qp = 4.5+ tsf)			Soil classifications based on Visual-Manual Procedure in general accordance with ASTM D 2488	
	X	2 - SS	21+22+40+21 N=62	17"	**FILL** : Sandy Silt to Silty Clay, hard, brown, contains gravel and sand (Qp = 4.5+ tsf)				
5 285.0	X	3 - SS	23+28+32+24 N=60	22"	**FILL** : Gravelly Silt with fine to coarse Sand, hard, brown, contains trace clay				
	X	4 - SS	26+18+40+50/4" N=58	22"	Continue: contains trace clay and portions of silty clay (Qp = 4.5+ tsf)		50/4"		
	X	5 - SS	25+41+26+27 N=67	18"	Continue: portions moist to wet				
10 280.0	X	6 - SS	42+32+17+10 N=49	20"	Continue: occasional moist to wet zones				
	X	7 - SS	11+25+27+26 N=52	20"	**FILL** : Sandy Gravel with Silt, very dense, brown, contains trace clay, occasional wet zones				
15 275.0	X	8 - SS	28+20+34+44 N=54	19"	Continued: contains trace clay and occasional silty clay seams (Qp = 4.0 tsf)				
	X	9 - SS	8+12+10+9 N=22	18"	**FILL** : Clayey Silt/Silty Clay, very stiff, brown to gray brown, contains trace fine to medium sand (Qp = 3.5-4.5 tsf)				
20 270.0	X	10 - SS	22+42+29+25 N=71	20"	**FILL** : Silty Sand with Gravel, very dense, brown, contains clay and zones of silty clay (Qp = 4.5 tsf)				
	X	11 - SS	19+15+15+16 N=30	18"	Continue: medium dense, moist				
25 265.0	X	12 - SS	16+12+11+12 N=23	14"	**NATURAL SOIL**: Silty Clay (CL), very stiff, brown (Qp = 4.5+ tsf)			Fill/Natural Soil contact approx. at 25'	
	X	13 - SS	10+14+12+13 N=26	18"	**NATURAL SOIL**: Silty Sand with Gravel (SM), medium dense, brown				
30 260.0									

(Continued)

Notes: 1. SPT performed with automatic safety hammer. 2. Installed 1" diameter piezometers with screening interval approx. from 19' to 24' and 30' to 35'.

HDR

	Project : Brunner Island Ash Basin #6 Geotechnical Exploration	Boring: **B09-3**
		Sheet: **2 of 2**
	Project Location: York Haven, PA	Location: Sta. 7+44 - Crest Coordinates: , Ground Surface Elevation: ± 290 ft. MSL Datum:
Client: PPL Allentown, PA	Project Number: 106864	

Boring Contractor:	CGC Geoservices
Boring Foreman:	Dan Bowles
Drilling Method:	4-1/4" HSA/SPT
Core Barrel:	N/A
Drilling Equipment:	Acker Soilmax
Boring Logged By:	BRR
Dates Started: 6/8/09	Finished: 6/9/09

Water Level Observations

	Date	Time	Casing (ft)	Water (ft)	Caved (ft)
Borehole - During Drilling	6/9/09	12:30 pm		30.9	
Piezometer B09-3A - 24 to 72 hrs	6/10/09	7:30 am		31.9	
Piezometer B09-3B - 24 to 72 hrs	6/10/09	7:31 am		23.6	
Piezometer B09-3A - Ext. Reading	6/15/09	7:30 am		32.9	
Piezometer B09-3B - Ext. Reading	6/15/09	7:31 am		23.6	

Depth & Elevation (Feet)	Sampling Type	Sample Name	Data	Rec. (in.)	Material Description & Classification	Lithology	PL / MC / LL; N-Value, blows/ft (0 / 50 / 100)	Laboratory Tests & Comments	Well
					NATURAL SOIL: Silty Sand with Gravel (SM), medium dense, brown *(Continued)*				
	X	14 - SS	8+16+16+17 N=32	15"	Continue: dense, wet to saturated			Hit water at approx. 33'	
35 255.0									
	X	15 - SS	25+41+50/4"	11"	Continue: dense, saturated		50/4" >>		
					PARTIALLY WEATHERED ROCK (PWR) Sampled as saturated brown silty sand with gravel with pieces of sandstone and shale in tip of sampler				
40 250.0					4-1/4" AUGER REFUSAL AT 41.0 FEET. Safety Hammer used for SPT. Bottom of Boring at 41 feet.				

Notes: 1. SPT performed with automatic safety hammer. 2. Installed 1" diameter piezometers with screening interval approx. from 19' to 24' and 30' to 35'.

HDR	Project : Brunner Island Ash Basin #6 Geotechnical Exploration	Boring: **B09-4**
	Project Location: York Haven, PA	Sheet: **1 of 1**
Client: PPL Allentown, PA	Project Number: 106864	Location: Sta. 7+44 - Downstream Slope Coordinates: , Ground Surface Elevation: ± 269.2 ft. MSL Datum:

Boring Contractor:	CGC Geoservices
Boring Foreman:	Mike Clinton
Drilling Method:	ROTARY/SPT
Core Barrel:	N/A
Drilling Equipment:	Skid
Boring Logged By:	BRR
Dates Started: 6/17/09	Finished: 6/18/09

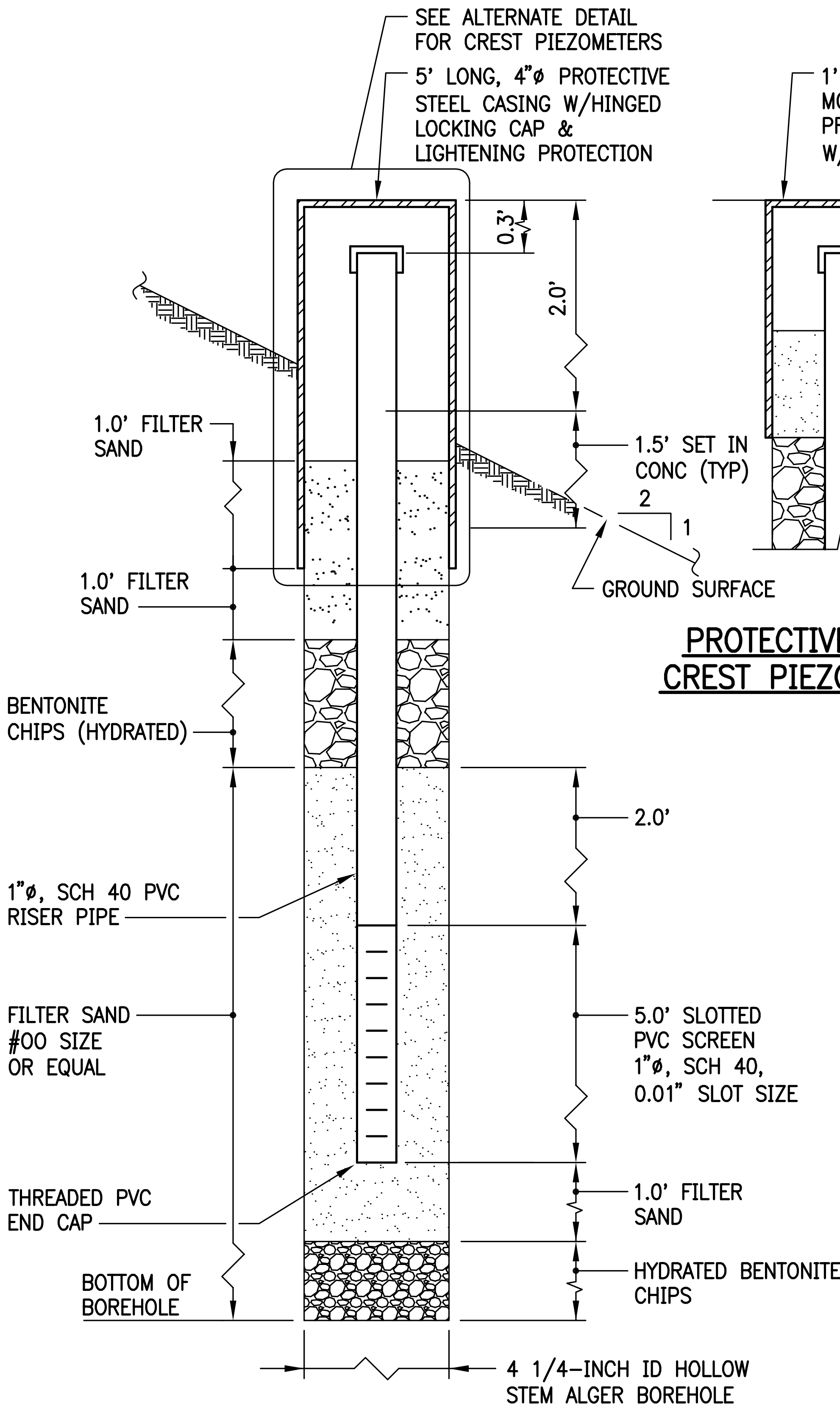
Water Level Observations

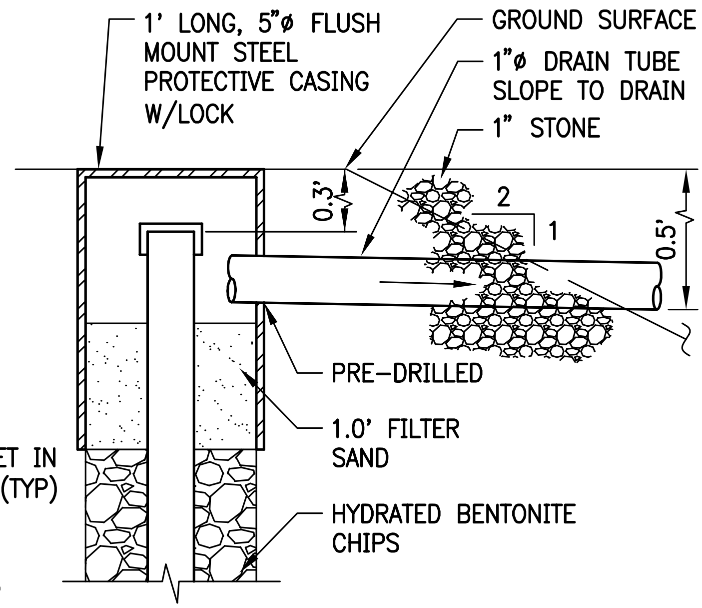
	Date	Time	Casing (ft)	Water (ft)	Caved (ft)
Completion (Borehole)	6/18/09	9:00 am	10.0	8.2	
During Drilling	6/18/09	2:30 pm		10.1	
Extended Reading	6/25/09	9:00 am		3.7	

Depth & Elevation (Feet)	Sampling Type	Sample Name	Data	Rec. (in.)	Material Description & Classification	Laboratory Tests & Comments
	SS	1 - SS	5+8+6+9 N=14	4"	**FILL** : Gravelly Silt, stiff, brown, contains trace sand, clay, and a piece of sandstone gravel stuck in shoe, moist to wet	Soil classifications based on Visual-Manual Procedure in general accordance with ASTM D 2488
	SS	2 - SS	4+7+24+33 N=31	3"	Continued: hard, larger gravel stuck in SPT shoe, dry to moist	
5 264.2	SS	3 - SS	32+28+27+12 N=55	15"	**FILL** : Gravelly Silt with fine to coarse Sand, hard, brown, contains large gravel at top of sample, moist to wet (wetter in more gravelly zones)	
	SS	4 - SS	4+5+8+10 N=13	14"	**NATURAL SOIL**: Clayey Silt (ML), stiff, brown to gray brown, contains occasional sand (Qp = 2.5-4.0 tsf)	
10 259.2	SS	5 - SS	20+20+26+28 N=46	9"	**NATURAL SOIL**: Silty Gravel with Sand (GM), dense, brown, contains pieces of sandstone, moist	Set 4" Casing to 10 ft Attempted 3" Shelby Tube at 10 ft 0" push (Refusal) 100% water loss drilling below 10 ft
	SS	6 - SS	31+50/0.1"	5"	Continued: moist to dry	
	SS	7 - SS	50/0	0"	**PARTIALLY WEATHERED ROCK (PWR)** Sampled as moist to dry brown silty sand with gravel	
					TRICONE REFUSAL AT 12.8 FEET. Safety Hammer used for SPT. Bottom of Boring at 12.8 feet.	

Lithology | PL MC LL | N-Value, blows/ft | 0 50 100 | 50/0.1" | Well

Notes: 1. SPT performed with automatic safety hammer. 2. Installed 1" diameter piezometer with screening interval approx. from 3.5' to 8.5'.





PROTECTIVE CASING DETAIL FOR
CREST PIEZOMETER B09-1, B09-3

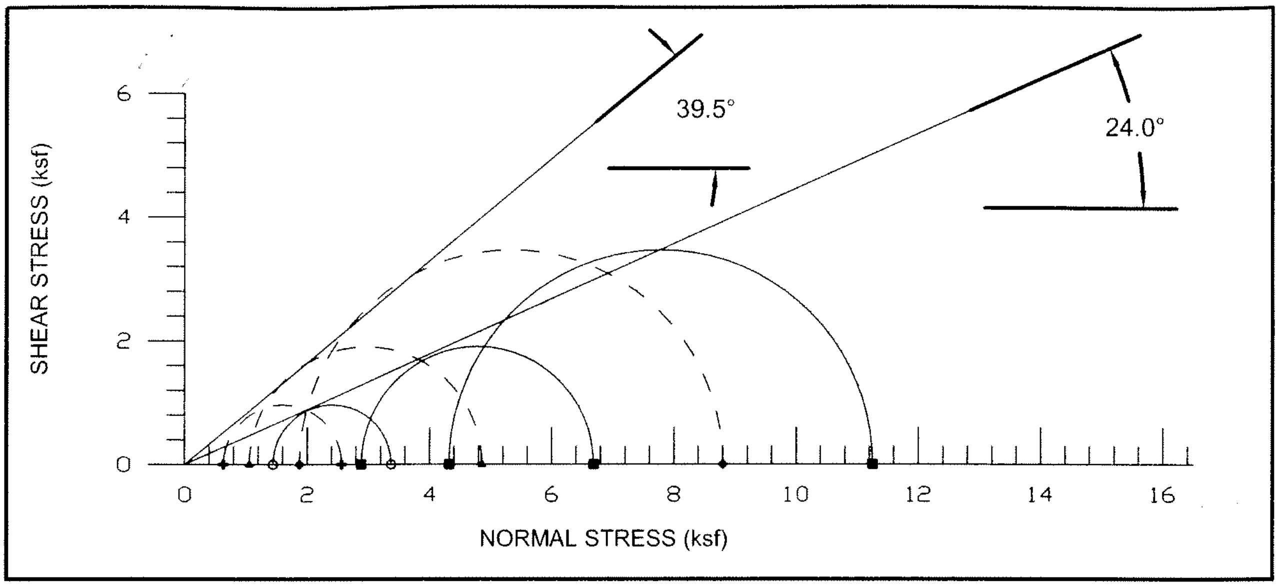
SCALE: N.T.S.

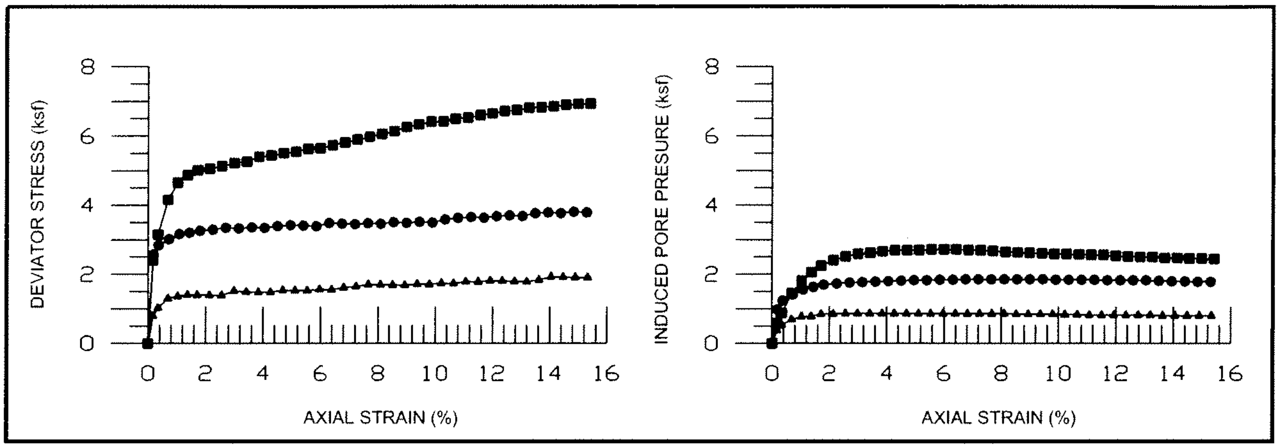
FIGURE 02552-1
TYPICAL OPEN STANDPIPE PIEZOMETER
DETAIL B09-2, B09-4

SCALE: N.T.S.

APPENDIX D
LABORATORY TESTING RESULTS

TRIAXIAL COMPRESSION TEST, "R-BAR" (ASTM D4767)





c = 0.00 (ksf) c' = 0.00 (ksf)
Φ = 24.0 ° Φ' = 39.5 °

Sample No.:	1	2	3
Minor Principal Stress (ksf):	1.44	2.88	4.32
Max. Deviator Stress(ksf):	1.93	3.81	6.93
Inital Height (in.):	5.90	5.90	5.90
Initial Diameter (in):	2.87	2.87	2.87
Saturation B-Parameter (%):	90.0	95.0	97.0
Initial Moisture (%):	8.3	8.3	8.3
Dry Unit Weight (pcf):	123.5	124.5	126.9

Remarks: Oversized material replacement performed on oversize portion (material with particle size greater than 1/2") in general accordance with USACE test methods (approximately 12 % by weight).

Sample Identification: B-09-1: Bulk No. 2
Sample Description: Red-brown GRAVEL, some silty clay, little fine to medium sand, trace coarse sand.

% Passing No. 200 Sieve: 32.0
USCS Class: GC

LEGEND:
- ● Sample 1
- ■ Sample 2
- ▲ Sample 3

Project: PPL Brunner Island, Ash Basin No. 6
Client: PPL Generation LLC.
Sample Identification: B09-1 Bulk Sample No. 2
Project No. 8146.ZA
Date/Checked By: BJD 7/09

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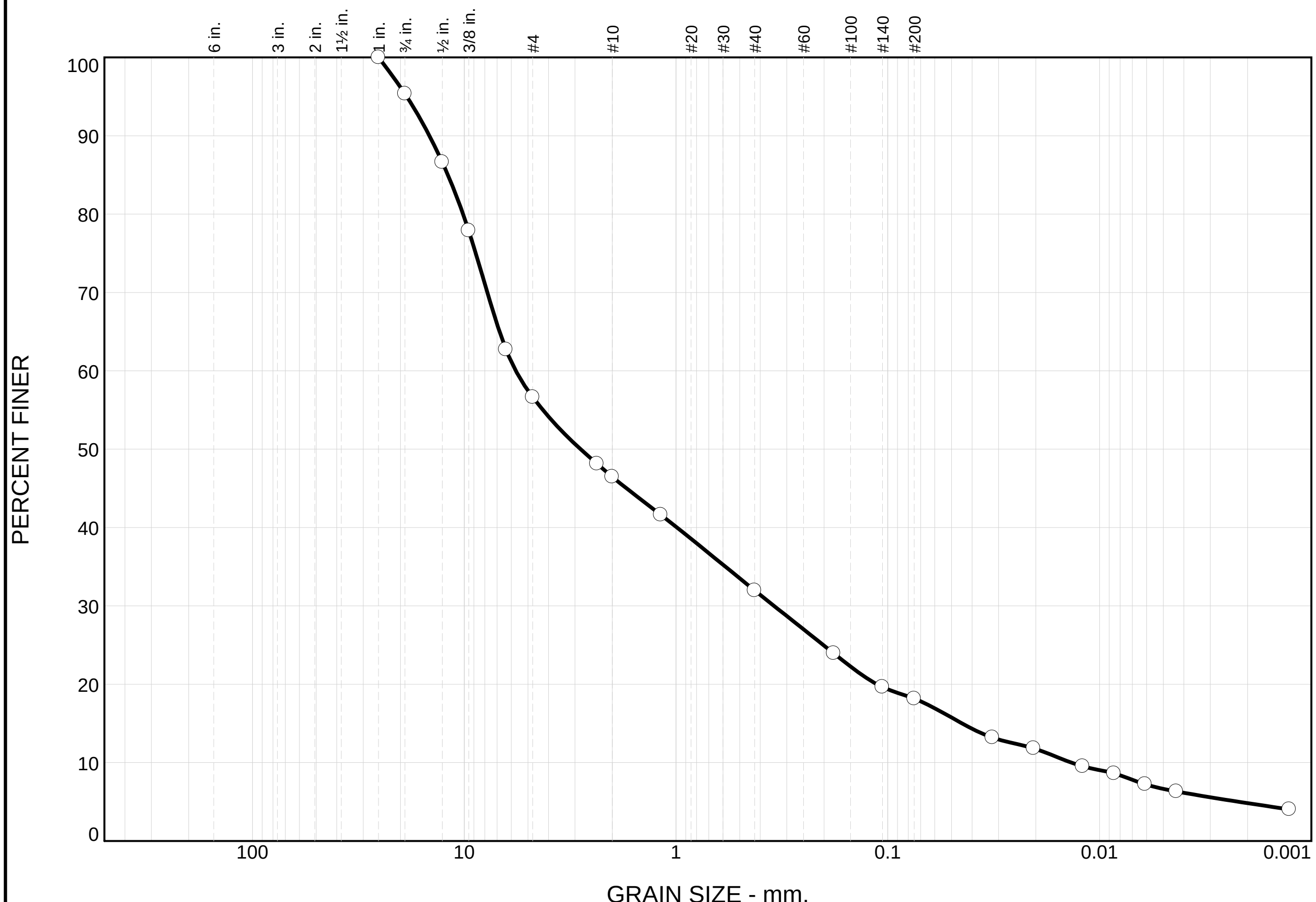
A Division of Duffield Associates

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	4.6	38.8	10.1	14.5	13.8	11.6	6.6

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	20	13	11.9430	5.7115	2.8216	0.3446	0.0446	0.0136	1.53	420.49

Material Description	USCS	AASHTO
○ USCS Classification: Silty clayey gravel with sand	GC-GM	

Project No. 08146.ZA **Client:** PPL Generation, LLC.

Project: PPL Brunner Island, Ash Basin No. 6

○ **Loc.:** Ash Basin No. 6 **Depth:** 4.0'-10.0' **Sample No.:** B09-1 Bulk No. 1

CUMBERLAND GEOSCIENCE CONSULTANTS

Carlisle, Pennsylvania

Remarks:

○B09-01 Bulk Sample No. 1
4.0'-10.0'

GRAIN SIZE DISTRIBUTION TEST DATA

7/22/2009

Client: PPL Generation, LLC.
Project: PPL Brunner Island, Ash Basin No. 6
Project Number: 08146.ZA
Location: Ash Basin No. 6
Depth: 4.0'-10.0' **Sample Number:** B09-1 Bulk No. 1
Material Description: USCS Classification: Silty clayey gravel with sand
Liquid Limit: 20 **Plastic Limit:** 13
USCS Classification: GC-GM
Testing Remarks: B09-01 Bulk Sample No. 1
4.0'-10.0'

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
1326.20	0.00	0.00	1"	0.00	100.0
			3/4"	61.63	95.4
			1/2"	177.30	86.6
			3/8"	293.22	77.9
			1/4"	494.40	62.7
			#4	575.00	56.6
			#8	687.80	48.1
			#10	709.80	46.5
50.00	0.00	0.00	#16	5.22	41.6
			#40	15.61	32.0
			#80	24.23	24.0
			#140	28.86	19.7
			#200	30.46	18.2

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 46.5
Weight of hydrometer sample =50
Hygroscopic moisture correction:
Moist weight and tare = 56.05
Dry weight and tare = 55.86
Tare weight = 31.05
Hygroscopic moisture = 0.8%
Table of composite correction values:

Temp., deg. C:	23.0	27.5	26.0	25.0	22.0	19.5
Comp. corr.:	-7.6	-8.6	-8.3	-8.0	-7.4	-6.9

Meniscus correction only = 0.5
Specific gravity of solids = 2.75
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 - 0.164 **x Rm**

Hydrometer Test Data (continued)

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer
2.00	23.0	22.0	14.4	0.0128	22.5	12.6	0.0321	13.2
5.00	23.0	20.5	12.9	0.0128	21.0	12.9	0.0205	11.8
15.00	23.0	18.0	10.4	0.0128	18.5	13.3	0.0120	9.5
30.00	23.0	17.0	9.4	0.0128	17.5	13.4	0.0085	8.6
60.00	23.0	15.5	7.9	0.0128	16.0	13.7	0.0061	7.2
120.00	23.0	14.5	6.9	0.0128	15.0	13.8	0.0043	6.3
1440.00	23.0	12.0	4.4	0.0128	12.5	14.2	0.0013	4.0

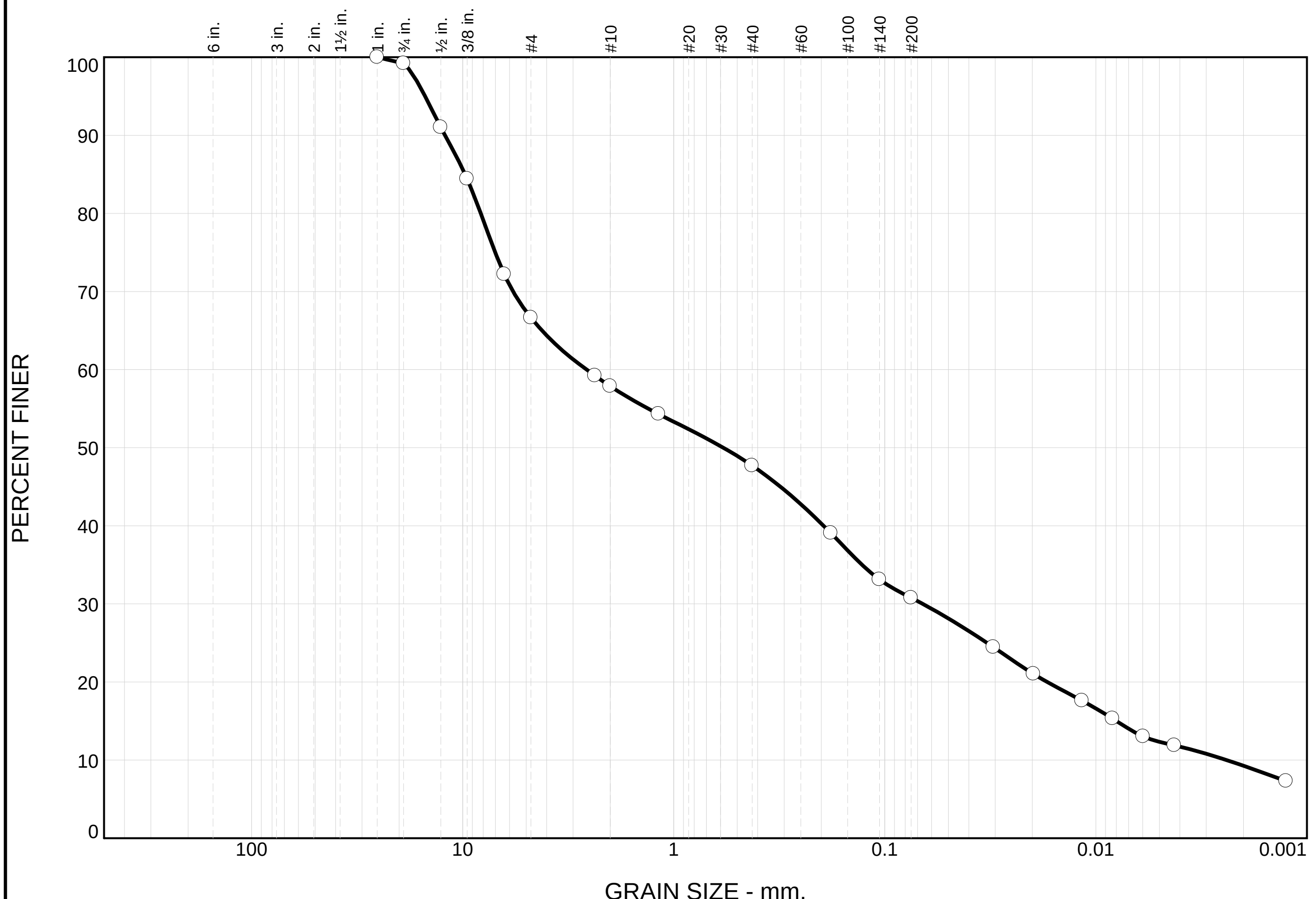
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	4.6	38.8	43.4	10.1	14.5	13.8	38.4	11.6	6.6	18.2

D_{10}	D_{15}	D_{20}	D_{30}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.0136	0.0446	0.1124	0.3446	2.8216	5.7115	10.1200	11.9430	14.5971	18.6778

Fineness Modulus	C_u	C_c
3.94	420.49	1.53

Particle Size Distribution Report



% +3"	% Gravel Coarse	% Gravel Fine	% Sand Coarse	% Sand Medium	% Sand Fine	% Fines Silt	% Fines Clay
0.0	0.8	32.6	8.7	10.2	16.9	18.5	12.3

LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
23	17	9.7328	2.5867	0.5823	0.0661	0.0080	0.0024	0.70	1075.34

Material Description	USCS	AASHTO
USCS Classification: Silty, clayey sand with gravel	SC-SM	

Project No. 08146.ZA **Client:** PPL Generation, LLC.

Project: PPL Brunner Island, Ash Basin No. 6

Loc.: Ash Basin No. 6 **Depth:** 15.0'-19.0' **Sample No.:** B09-1 Bulk No. 2

CUMBERLAND GEOSCIENCE CONSULTANTS

Carlisle, Pennsylvania

Remarks:

B09-1 Bulk Sample No. 2
15.0'-19.0'

GRAIN SIZE DISTRIBUTION TEST DATA

7/22/2009

Client: PPL Generation, LLC.
Project: PPL Brunner Island, Ash Basin No. 6
Project Number: 08146.ZA
Location: Ash Basin No. 6
Depth: 15.0'-19.0' **Sample Number:** B09-1 Bulk No. 2
Material Description: USCS Classification: Silty, clayey sand with gravel
Liquid Limit: 23 **Plastic Limit:** 17
USCS Classification: SC-SM
Testing Remarks: B09-1 Bulk Sample No. 2
15.0'-19.0'

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
1471.50	0.00	0.00	1"	0.00	100.0
			3/4"	11.62	99.2
			1/2"	132.04	91.0
			3/8"	229.11	84.4
			1/4"	409.10	72.2
			#4	490.80	66.6
			#8	600.00	59.2
			#10	619.80	57.9
50.00	0.00	0.00	#16	3.08	54.3
			#40	8.79	47.7
			#80	16.26	39.1
			#140	21.39	33.1
			#200	23.41	30.8

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 57.9
Weight of hydrometer sample =50
Hygroscopic moisture correction:
Moist weight and tare = 50.07
Dry weight and tare = 49.85
Tare weight = 25.07
Hygroscopic moisture = 0.9%
Table of composite correction values:

Temp., deg. C:	23.0	27.5	26.0	25.0	22.0	19.5
Comp. corr.:	-7.6	-8.6	-8.3	-8.0	-7.4	-6.9

Meniscus correction only = 0.5
Specific gravity of solids = 2.75
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 - 0.164 **x Rm**

Hydrometer Test Data (continued)

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer
2.00	23.0	29.0	21.4	0.0128	29.5	11.5	0.0306	24.5
5.00	23.0	26.0	18.4	0.0128	26.5	11.9	0.0197	21.0
15.00	23.0	23.0	15.4	0.0128	23.5	12.4	0.0116	17.6
30.00	23.0	21.0	13.4	0.0128	21.5	12.8	0.0083	15.3
60.00	23.0	19.0	11.4	0.0128	19.5	13.1	0.0060	13.0
120.00	23.0	18.0	10.4	0.0128	18.5	13.3	0.0042	11.9
1440.00	23.0	14.0	6.4	0.0128	14.5	13.9	0.0013	7.3

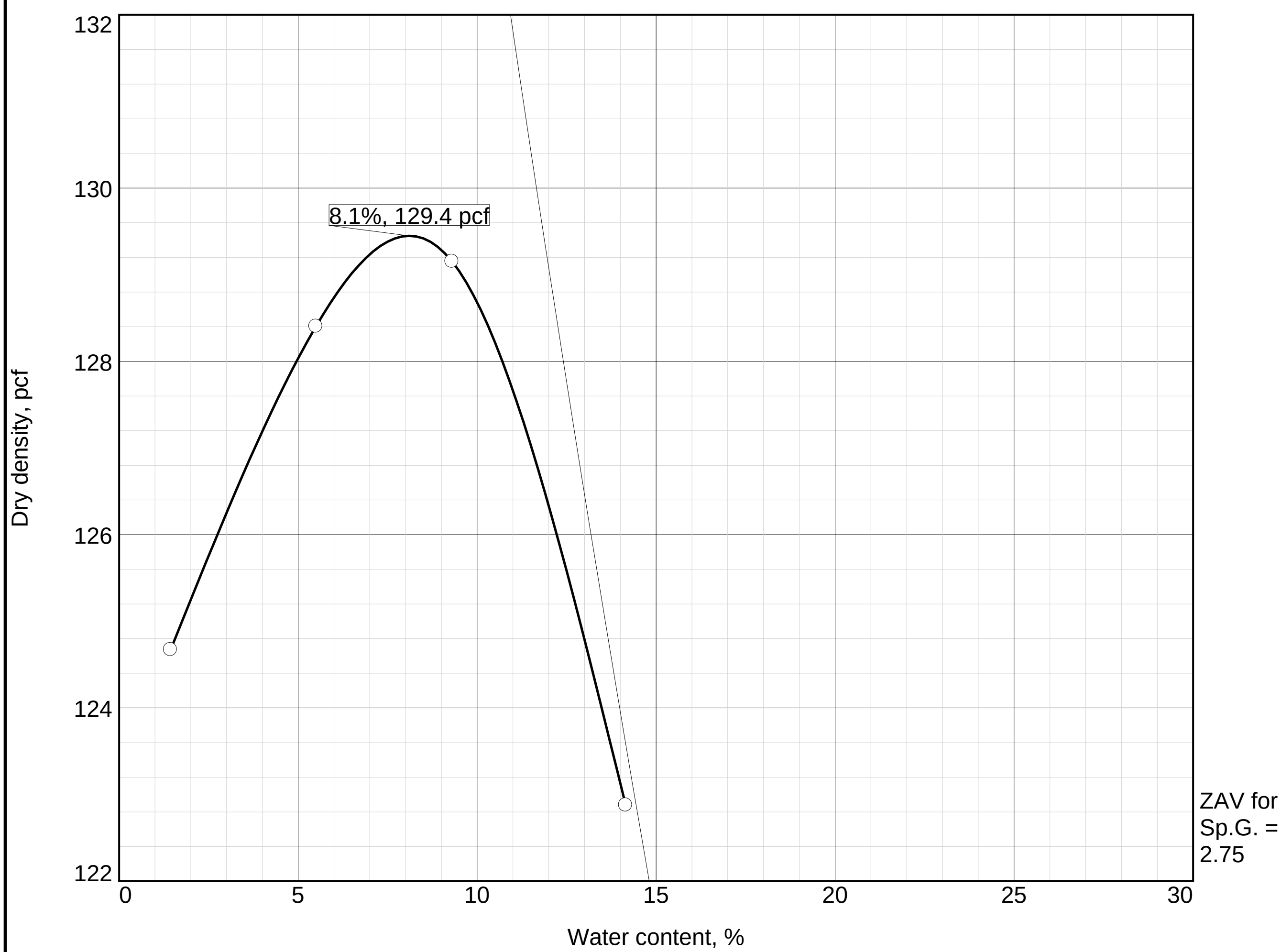
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.8	32.6	33.4	8.7	10.2	16.9	35.8	18.5	12.3	30.8

D_{10}	D_{15}	D_{20}	D_{30}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.0024	0.0080	0.0170	0.0661	0.5823	2.5867	8.2136	9.7328	12.1247	15.0591

Fineness Modulus	C_u	C_c
3.05	1075.34	0.70

COMPACTION TEST REPORT



Test specification: ASTM D 698-00a Method B Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in.	% < No.200
	USCS	AASHTO						
15.0'-19.0'	SC-SM			2.75	23	7	15.6	30.8

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 129.4 pcf Optimum moisture = 8.1 %	USCS Classification: Silty, clayey sand with gravel

Project No. 08146.ZA **Client:** PPL Generation, LLC.
Project: PPL Brunner Island, Ash Basin No. 6

○ **Loc.:** Ash Basin No. 6 **Depth:** 15.0'-19.0'

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Remarks:
B09-1 Bulk Sample No. 2
15.0'-19.0'

MOISTURE DENSITY TEST DATA

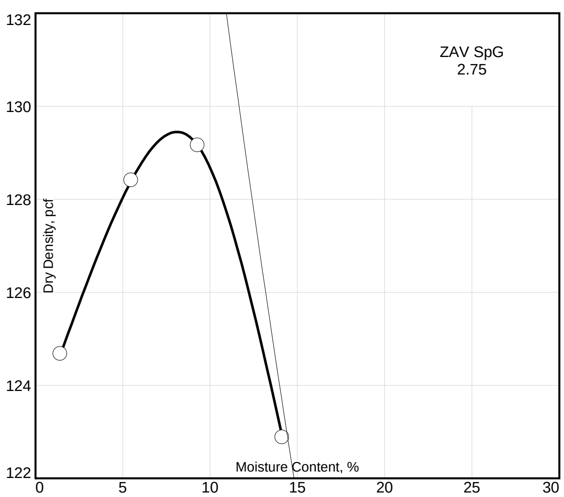
7/22/2009

Client: PPL Generation, LLC.
Project: PPL Brunner Island, Ash Basin No. 6
Project Number: 08146.ZA
Location: Ash Basin No. 6
Depth: 15.0'-19.0' **Sample Number:** B09-1 Bulk No. 2
Description: USCS Classification: Silty, clayey sand with gravel
USCS Classification: SC-SM
Liquid Limit: 23 **Plasticity Index:** 7
Testing Remarks: B09-1 Bulk Sample No. 2
15.0'-19.0'
Percent passing 3/8 in. sieve: 84.4

Test Data and Results

Test Specification:

Type of Test: ASTM D 698-00a Method B Standard
Mold Dia: 4.00 **Hammer Wt.:** 5.5 lb. **Drop:** 12 in. **Layers:** three **Blows per Layer:** 25



Point No.	1	2	3	4
Wt. M+S	13.76	14.06	14.25	14.22
Wt. M	9.54	9.54	9.54	9.54
Wt. W+T	92.2	118.6	139.4	113.7
Wt. D+T	91.2	114.1	130.2	103.4
Tare	30.8	31.7	31.1	31.2
Moist.	1.6	5.5	9.3	14.2
Wt. W+T	89.9	113.2	145.9	125.0
Wt. D+T	89.1	108.9	135.6	112.7
Tare	25.1	31.4	25.2	25.2
Moist.	1.2	5.5	9.3	14.1
Moist.*	1.4	5.5	9.3	14.1
Dry Den.*	124.7	128.4	129.2	122.9

Test Results: **Max. Dry Den.=** 129.4 pcf **Opt. Moist.=** 8.1%

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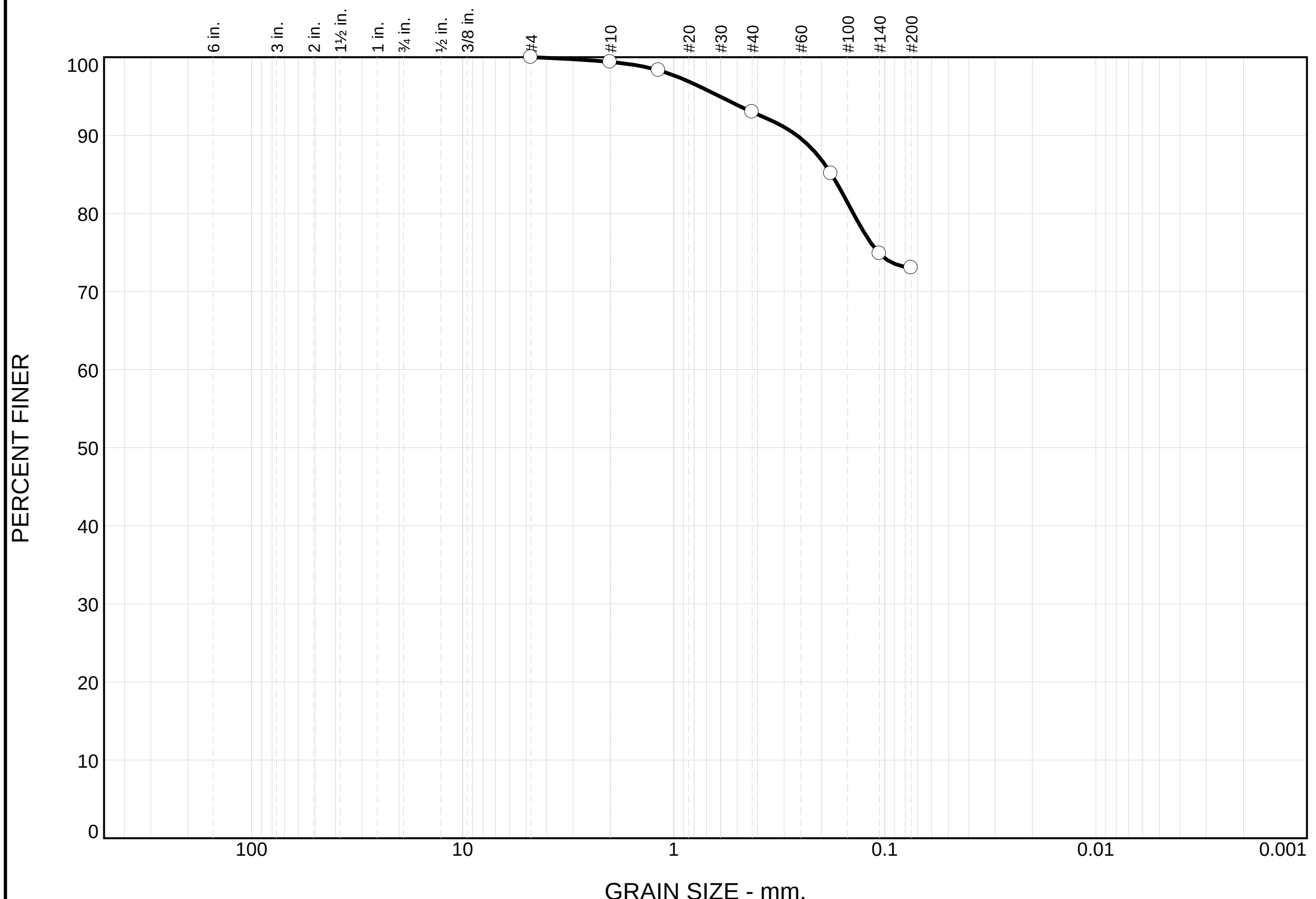
Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.6	6.4	20.0	73.0	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	30	20	0.1788							

Material Description	USCS	AASHTO
○ USCS Classification: Lean clay with sand	CL	

Project No. 08146.ZA **Client:** PPL Generation, LLC.
Project: PPL Brunner Island, Ash Basin No. 6

○ **Loc.:** Ash Basin No. 6 **Depth:** 29.0'-30.0' **Sample No.:** B09-1 UD-14

CUMBERLAND GEOSCIENCE CONSULTANTS

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Remarks:
○B09-1 UD-14
29.0'-30.0'
NMC=19.1%
#200 Wash

GRAIN SIZE DISTRIBUTION TEST DATA

7/22/2009

Client: PPL Generation, LLC.
Project: PPL Brunner Island, Ash Basin No. 6
Project Number: 08146.ZA
Location: Ash Basin No. 6
Depth: 29.0'-30.0' **Sample Number:** B09-1 UD-14
Material Description: USCS Classification: Lean clay with sand
Liquid Limit: 30 **Plastic Limit:** 20
USCS Classification: CL
Testing Remarks: B09-1 UD-14
29.0'-30.0'
NMC=19.1%
#200 Wash

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 128.68
Tare Wt. = 0.00
Minus #200 from wash = 73.0%

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
477.29	0.00	0.00	#4	0.00	100.0
			#10	2.93	99.4
			#16	7.99	98.3
			#40	33.48	93.0
			#80	71.01	85.1
			#140	119.98	74.9
			#200	128.68	73.0

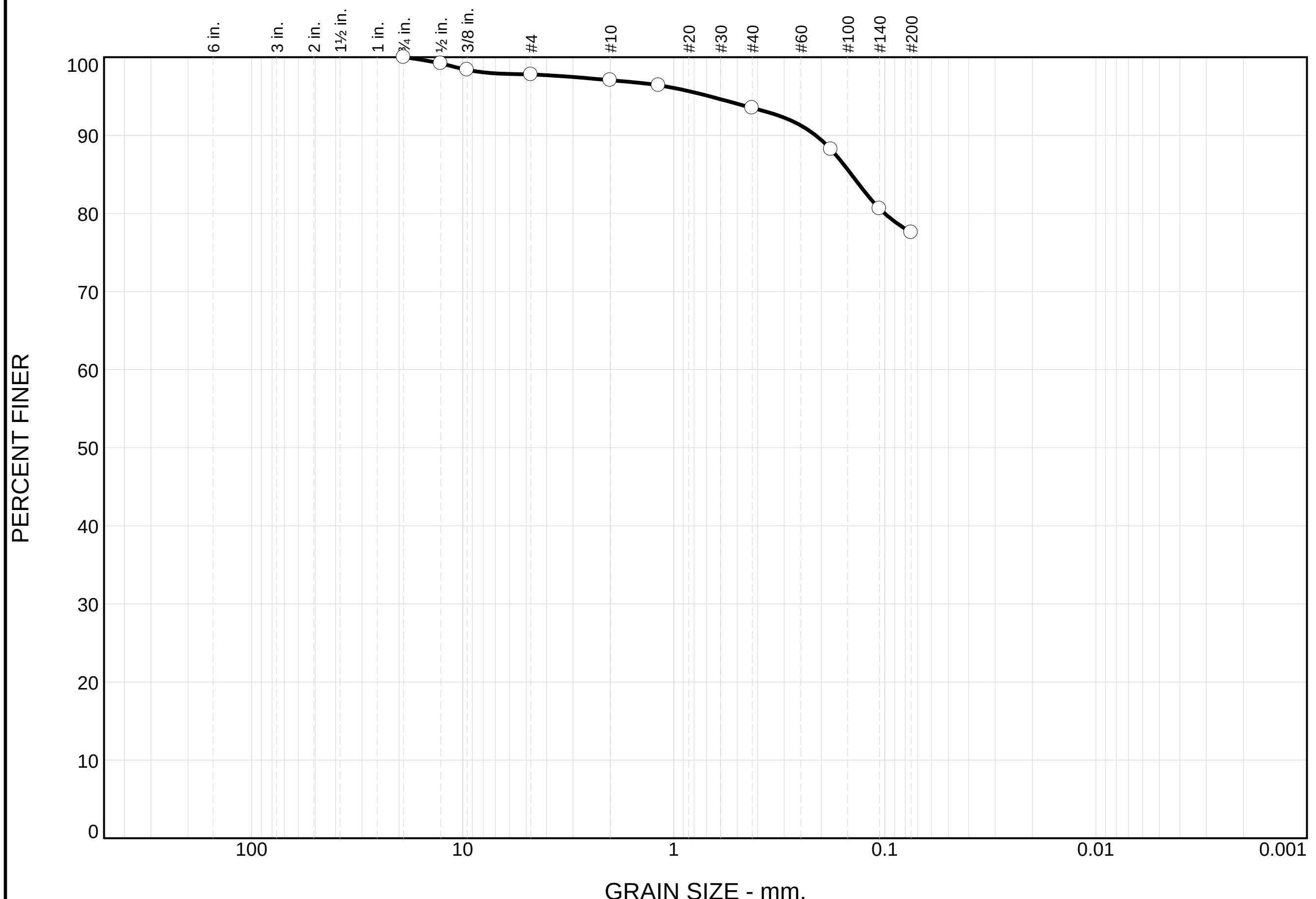
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.6	6.4	20.0	27.0			73.0

D_{10}	D_{15}	D_{20}	D_{30}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
						0.1409	0.1788	0.2611	0.6070

Fineness Modulus
0.35

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.2	0.7	3.6	15.9	77.6	

LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
34	21	0.1441							

Material Description	USCS	AASHTO
USCS Classification: Lean clay with sand	CL	

Project No. 08146.ZA **Client:** PPL Generation, LLC.
Project: PPL Brunner Island, Ash Basin No. 6

Loc.: Ash Basin No. 6 **Depth:** 15.0'-16.6' **Sample No.:** B09-2 UD-7

Remarks:
B09-2 UD-7
15.0'-16.0'
NMC=26.7%
#200 Wash

CUMBERLAND GEOSCIENCE CONSULTANTS

Carlisle, Pennsylvania

GRAIN SIZE DISTRIBUTION TEST DATA

7/22/2009

Client: PPL Generation, LLC.
Project: PPL Brunner Island, Ash Basin No. 6
Project Number: 08146.ZA
Location: Ash Basin No. 6
Depth: 15.0'-16.6' **Sample Number:** B09-2 UD-7
Material Description: USCS Classification: Lean clay with sand
Liquid Limit: 34 **Plastic Limit:** 21
USCS Classification: CL
Testing Remarks: B09-2 UD-7
15.0'-16.0'
NMC=26.7%
#200 Wash

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 71.72
Tare Wt. = 0.00
Minus #200 from wash = 77.6%

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
319.50	0.00	0.00	3/4"	0.00	100.0
			1/2"	2.54	99.2
			3/8"	5.17	98.4
			#4	7.07	97.8
			#10	9.40	97.1
			#16	11.48	96.4
			#40	20.73	93.5
			#80	37.71	88.2
			#140	61.95	80.6
			#200	71.72	77.6

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	2.2	2.2	0.7	3.6	15.9	20.2			77.6

D_{10}	D_{15}	D_{20}	D_{30}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
						0.1003	0.1441	0.2126	0.6782

Fineness Modulus
0.38

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Shelby Tube Extraction and Unit Weight

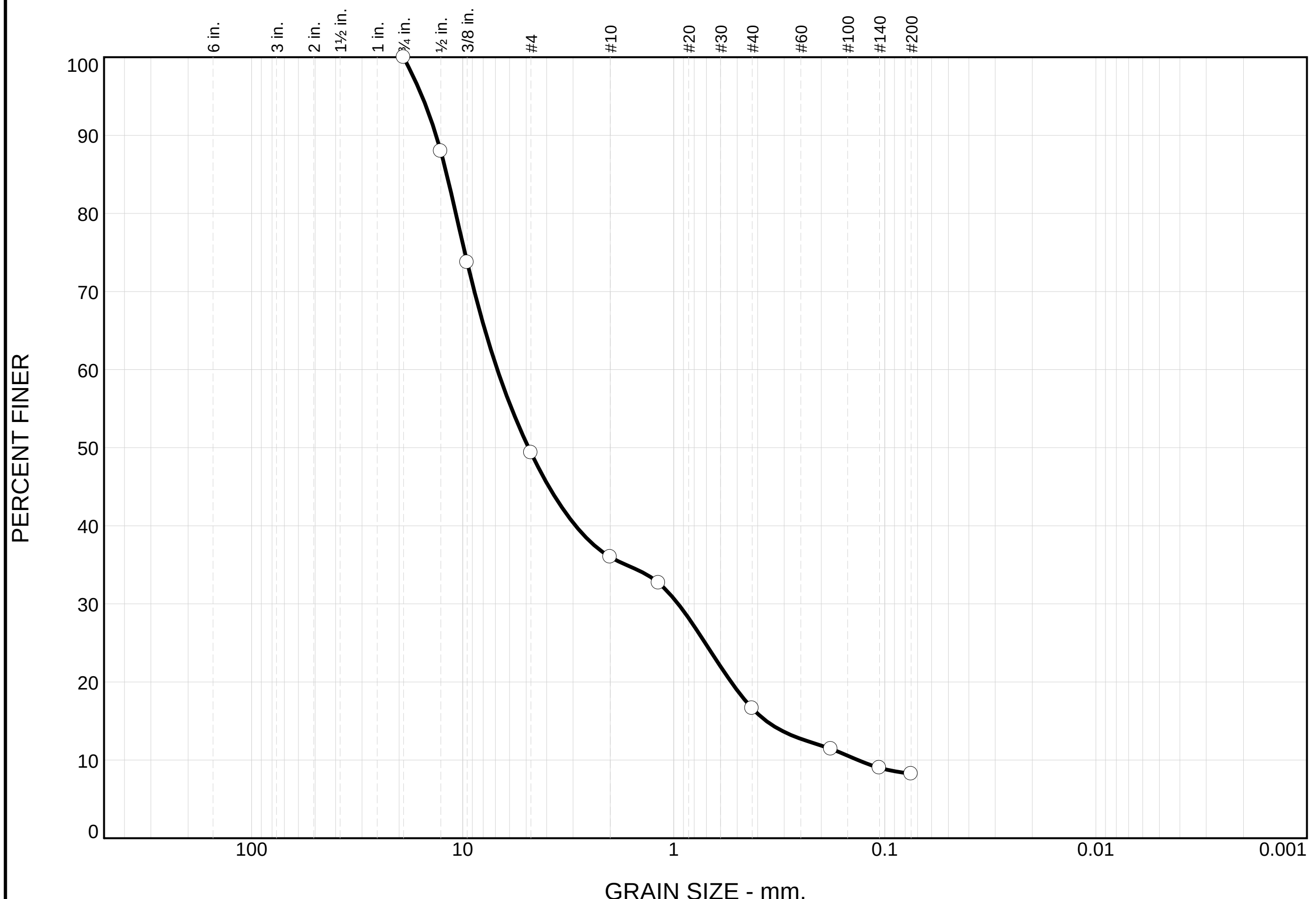
ASTM D2397

Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method

Sample Number	Percent Water	Wet Unit Weight (PCF)	Dry Unit Weight (PCF)
B09-1, UD-14, 29.0'-30.0'	19.1%	130.5	105.5
B09-2, UD-7, 15.0'-16.6'	26.7%	129.7	95.1

Project No. 08146.ZA
PPL Brunner Island / Ash Basin No. 6
PPL Generation LLC
July 22, 2009

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	50.6	13.4	19.4	8.4	8.2	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	0	0	11.8987	6.8490	4.8754	0.9536	0.3639	0.1337	0.99	51.21

Material Description	USCS	AASHTO
○ USCS Classification: Poorly graded gravel with silt and sand	GP-GM	

Project No. 08146.ZA **Client:** PPL Generation, LLC.
Project: PPL Brunner Island, Ash Basin No. 6

○ **Loc.:** Ash Basin No. 6 **Depth:** 13.0'-15.0' **Sample No.:** B09-3 SPT-7

Remarks:
○B09-3 SPT-7
13.0'-15.0'
NMC=6.0%
#200 Wash
Non-Plastic

CUMBERLAND GEOSCIENCE CONSULTANTS

Carlisle, Pennsylvania

GRAIN SIZE DISTRIBUTION TEST DATA

7/22/2009

Client: PPL Generation, LLC.
Project: PPL Brunner Island, Ash Basin No. 6
Project Number: 08146.ZA
Location: Ash Basin No. 6
Depth: 13.0'-15.0' **Sample Number:** B09-3 SPT-7
Material Description: USCS Classification: Poorly graded gravel with silt and sand
Liquid Limit: 0 **Plastic Limit:** 0
USCS Classification: GP-GM
Testing Remarks: B09-3 SPT-7
13.0'-15.0'
NMC=6.0%
#200 Wash
Non-Plastic

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 180.19
Tare Wt. = 0.00
Minus #200 from wash = 8.2%

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
196.37	0.00	0.00	3/4"	0.00	100.0
			1/2"	23.64	88.0
			3/8"	51.58	73.7
			#4	99.44	49.4
			#10	125.67	36.0
			#16	132.18	32.7
			#40	163.72	16.6
			#80	173.92	11.4
			#140	178.68	9.0
			#200	180.19	8.2

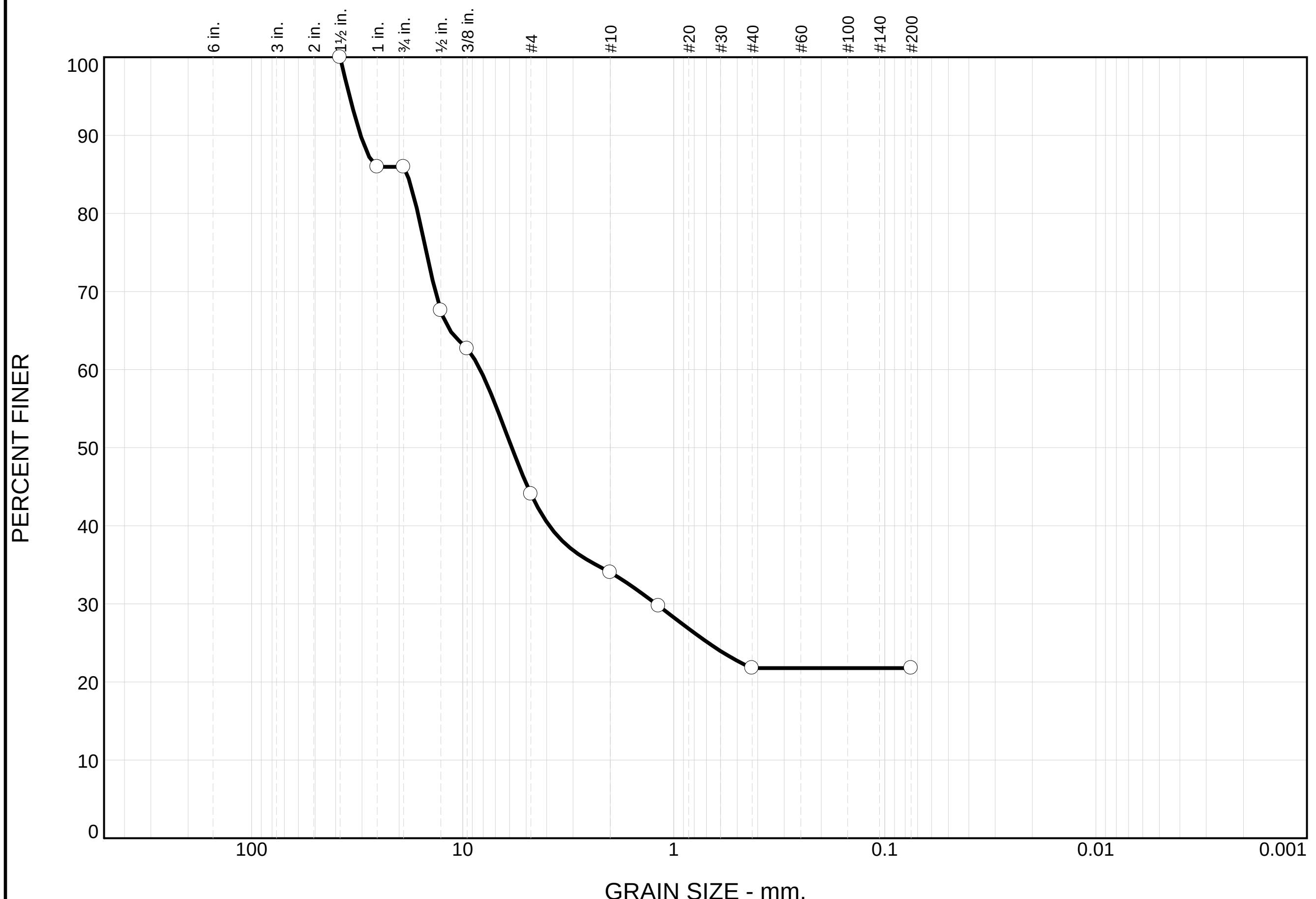
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	50.6	50.6	13.4	19.4	8.4	41.2			8.2

D_{10}	D_{15}	D_{20}	D_{30}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.1337	0.3639	0.5348	0.9536	4.8754	6.8490	10.7694	11.8987	13.3581	15.5722

Fineness Modulus	C_u	C_c
4.61	51.21	0.99

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	14.0	41.9	10.1	12.2	0.0	21.8	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	0	0	18.3305	8.2633	5.8498	1.2133				

Material Description	USCS	AASHTO
○ USCS Classification: Silty gravel with sand	GM	

Project No. 08146.ZA **Client:** PPL Generation, LLC.
Project: PPL Brunner Island, Ash Basin No. 6

○ **Loc.:** Ash Basin No. 6 **Depth:** 12.0'-12.6' **Sample No.:** B09-4 SPT-6

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Remarks:
○B09-4 SPT-6
12.0'-12.6'
Refusal at 12.8'
NMC=7.3%
No LL/PL Data for Classification

GRAIN SIZE DISTRIBUTION TEST DATA

7/22/2009

Client: PPL Generation, LLC.
Project: PPL Brunner Island, Ash Basin No. 6
Project Number: 08146.ZA
Location: Ash Basin No. 6
Depth: 12.0'-12.6' **Sample Number:** B09-4 SPT-6
Material Description: USCS Classification: Silty gravel with sand
Liquid Limit: 0 **Plastic Limit:** 0
USCS Classification: GM
Testing Remarks: B09-4 SPT-6
12.0'-12.6'
Refusal at 12.8'
NMC=7.3%
No LL/PL Data for Classification

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 185.19
Tare Wt. = 0.00
Minus #200 from wash = 21.8%

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
236.76	0.00	0.00	1.5"	0.00	100.0
			1"	33.25	86.0
			3/4"	33.25	86.0
			1/2"	76.76	67.6
			3/8"	88.36	62.7
			#4	132.41	44.1
			#10	156.19	34.0
			#16	166.32	29.8
			#40	185.19	21.8

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	14.0	41.9	55.9	10.1	12.2	0.0	22.3			21.8

D_{10}	D_{15}	D_{20}	D_{30}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
			1.2133	5.8498	8.2633	16.2825	18.3305	30.4593	34.3407

Fineness Modulus
4.75

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NATURAL WATER CONTENT DETERMINATIONS

ASTM DESIGNATION: D 2216

STANDARD TEST METHOD FOR LABORATORY DETERMINATION OF WATER (MOISTURE) CONTENT OF SOIL, ROCK AND SOIL-AGGREGATE MIXTURES

Boring No.	Sample No.	Depth (ft)	Percent Water
B09-1	SPT-13	27.0'-29.0'	18.2%
B09-1	UD-14	29.0'-30.0'	19.1%
B09-1	SPT-15	33.0'-35.0'	20.4%
B09-2	SPT-4	6.0'-8.0'	6.8%
B09-2	UD-7	15.0'-16.6'	26.7%
B09-3	SPT-7	13.0'-15.0'	6.0%
B09-4	SPT-4	7.0'-9.0'	16.2%
B09-4	SPT-6	12.0'-12.6'	7.3%

Project No. 08146.ZA
PPL Brunner Island / Ash Basin No. 6
PPL Generation LLC
July 22, 2009

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ATTERBERG LIMITS

ASTM DESIGNATION: D 4318

STANDARD TEST METHOD FOR LABORATORY DETERMINATION
OF LIQUID AND PLASTIC LIMITS OF SOIL

Boring No.	Sample No.	Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index
B09-1	Bulk-1	4.0'-10.0'	20	13	7
B09-1	Bulk-2	15.0'-19.0'	23	17	6
B09-1	SPT-13	27.0'-29.0'	24	21	3
B09-1	UD-14	29.0'-30.0'	30	20	10
B09-2	UD-7	15.0'-16.6'	34	21	13
B09-3	SPT-7	13.0'-15.0'	Non Plastic		

Project No. 08146.ZA
PPL Brunner Island / Ash Basin No. 6
PPL Generation LLC
July 22, 2009

APPENDIX E
STABILITY ANALYSIS RESULTS

INITIAL ANALYSES
10-YEAR FLOOD RAPID DRAWDOWN
(VERIFIES METHODOLOGY & PARAMETERS)

Brunner Island - Ash Basin #6 - Sta.21+80 - Rapid Drawdown (10 yr Flood)

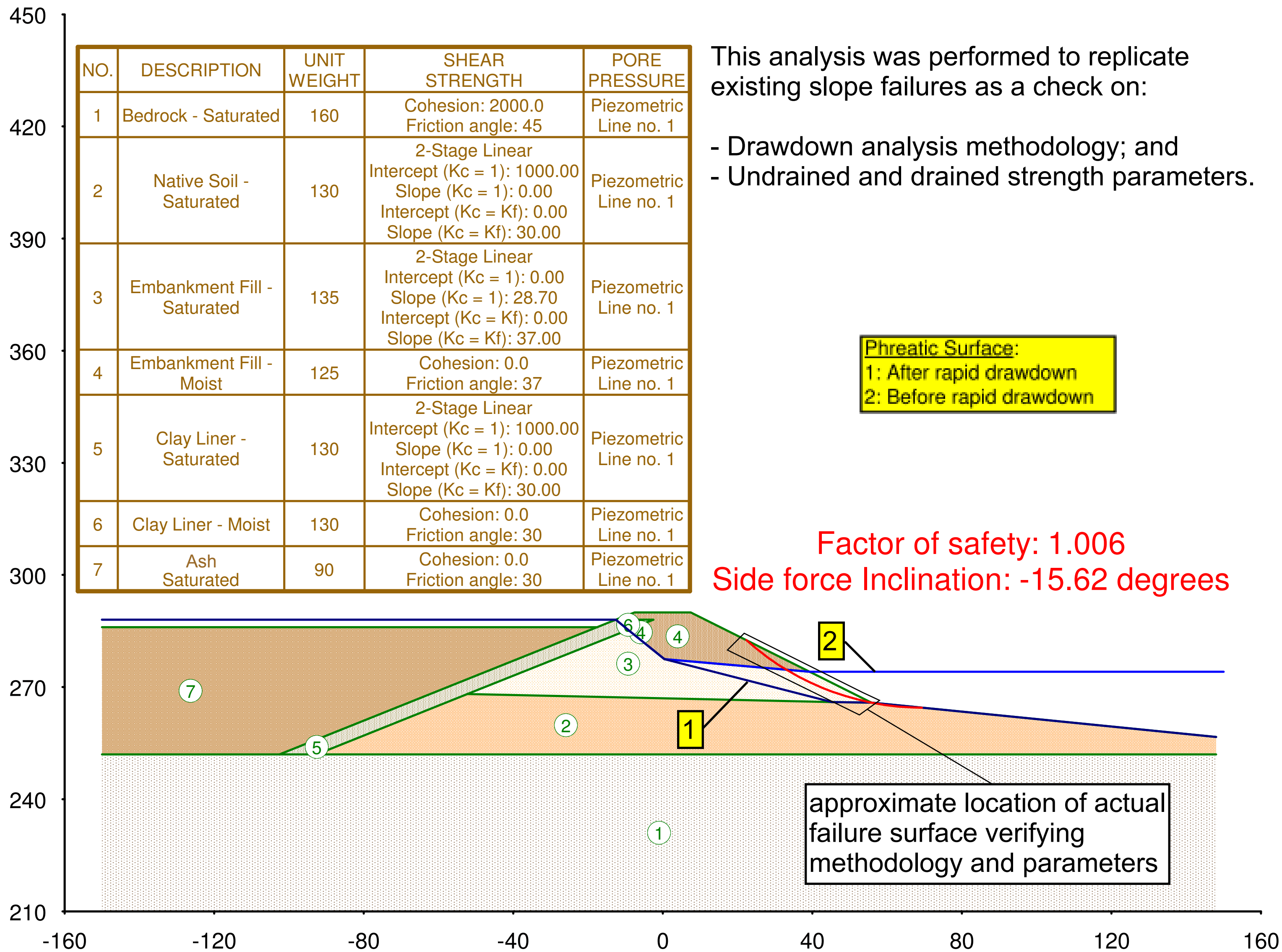
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 28.70 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 37.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

This analysis was performed to replicate existing slope failures as a check on:

- Drawdown analysis methodology; and
- Undrained and drained strength parameters.

Phreatic Surface:
1: After rapid drawdown
2: Before rapid drawdown

Factor of safety: 1.006
Side force Inclination: -15.62 degrees



Filename: C:\PPL_AshBasin\Brunner_Analysis_2009\Analysis\Brunner Island_Ash Basin No.6_Sta.21+80_Drawdown_1(Time: 10:55:260.UT4

Brunner Island - Ash Basin No.6 - Sta. 21+80 - Rapid Drawdown (10 yr Flood)

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 27.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 34.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 34	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

This analysis was performed to replicate existing slope failures as a check on:

- Drawdown analysis methodology; and
- Undrained and drained strength parameters.

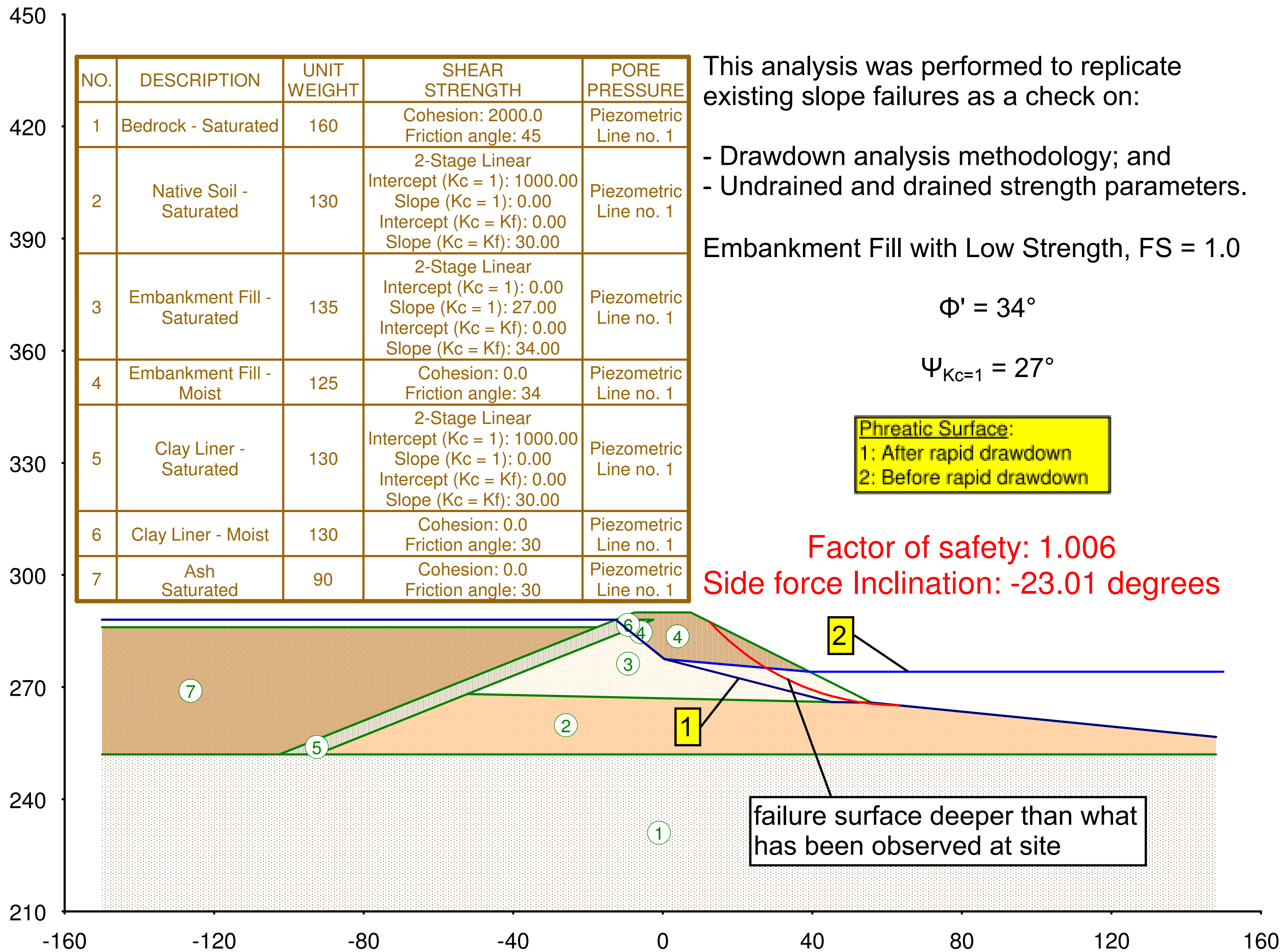
Embankment Fill with Low Strength, FS = 1.0

$\Phi' = 34°$

$\Psi_{Kc=1} = 27°$

Phreatic Surface:
1: After rapid drawdown
2: Before rapid drawdown

Factor of safety: 1.006
Side force Inclination: -23.01 degrees



Brunner Island - Ash Basin #6 - Sta.21+80 - Rapid Drawdown (10 yr Flood)

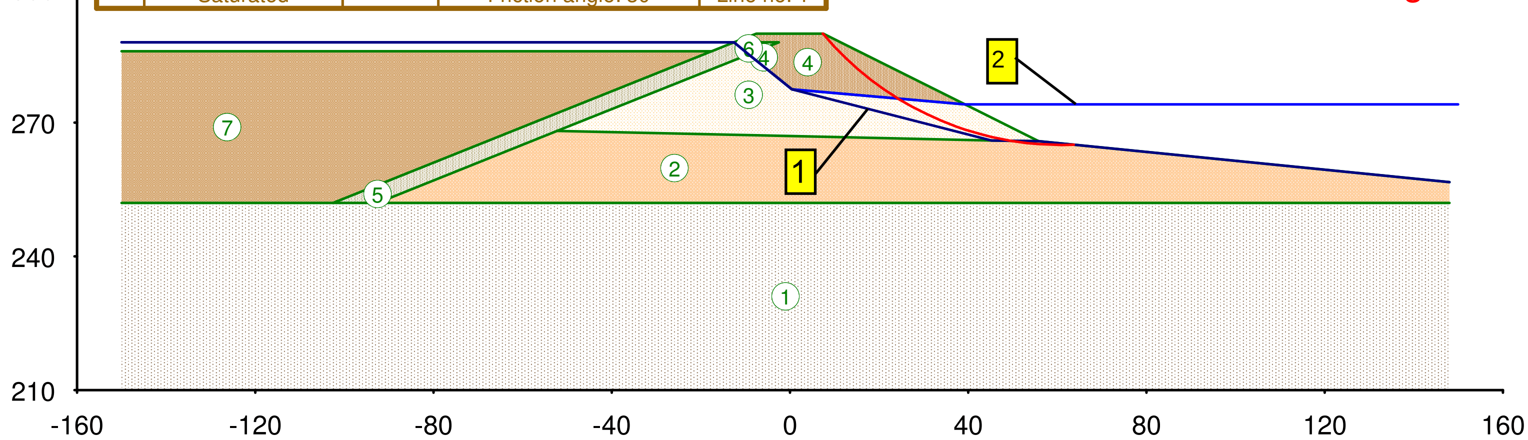
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 28.70 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 37.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

This analysis was performed to replicate existing slope failures as a check on:

- Drawdown analysis methodology; and
- Undrained and drained strength parameters.

This factor of safety greater than 1.0 concurs with the lack of evidence of deep failure surfaces at site.

Factor of safety: 1.142
Side force Inclination: -23.06 degrees



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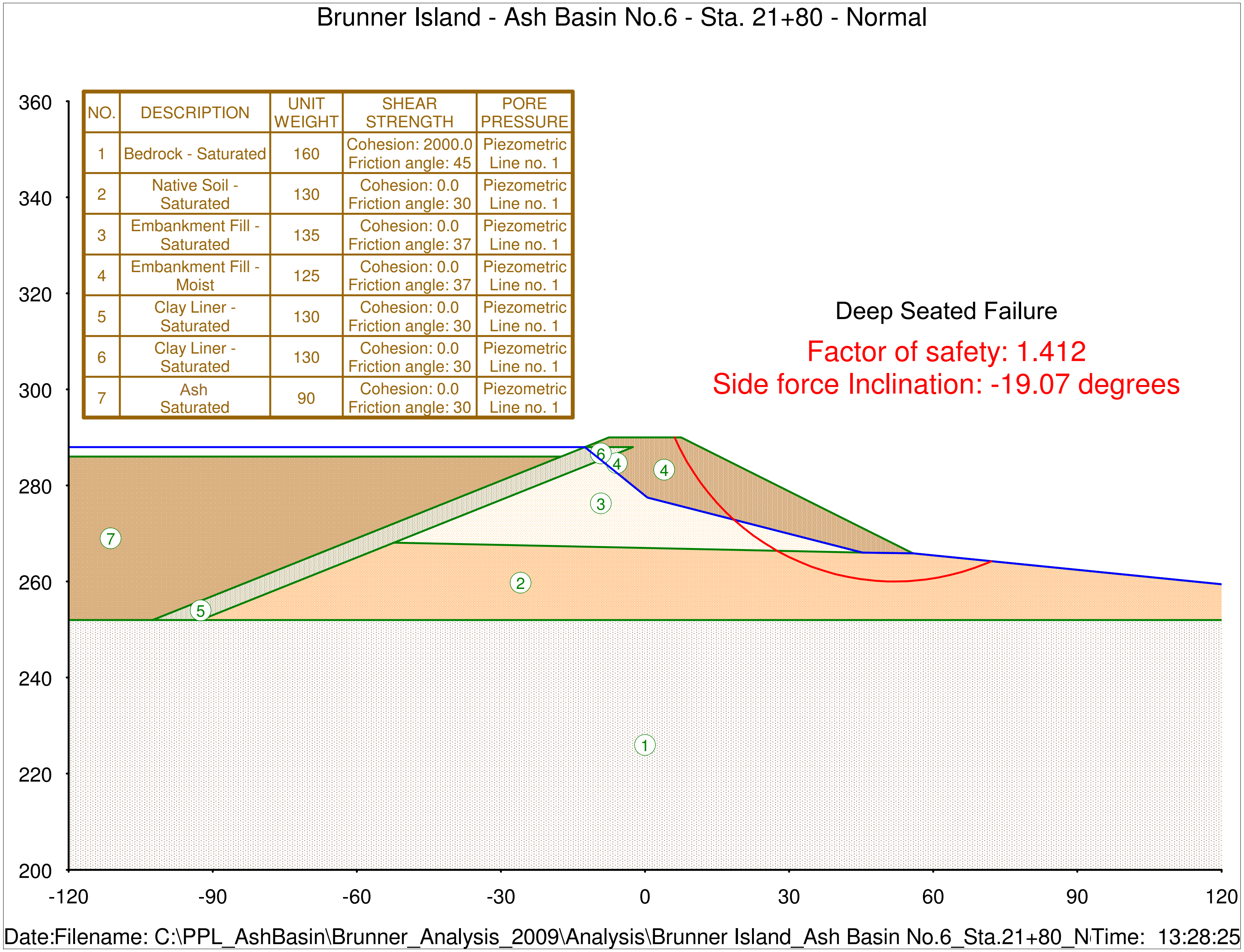
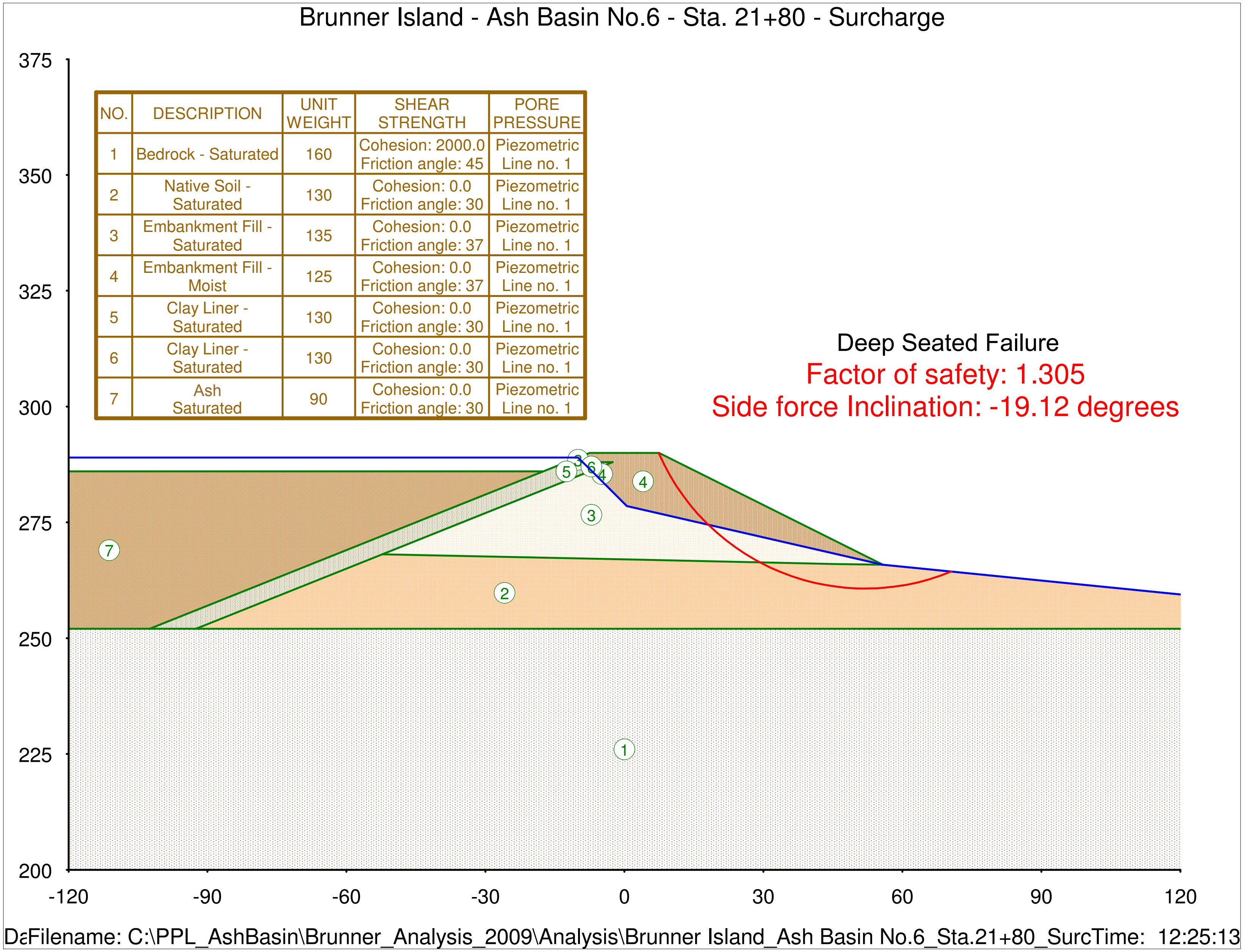
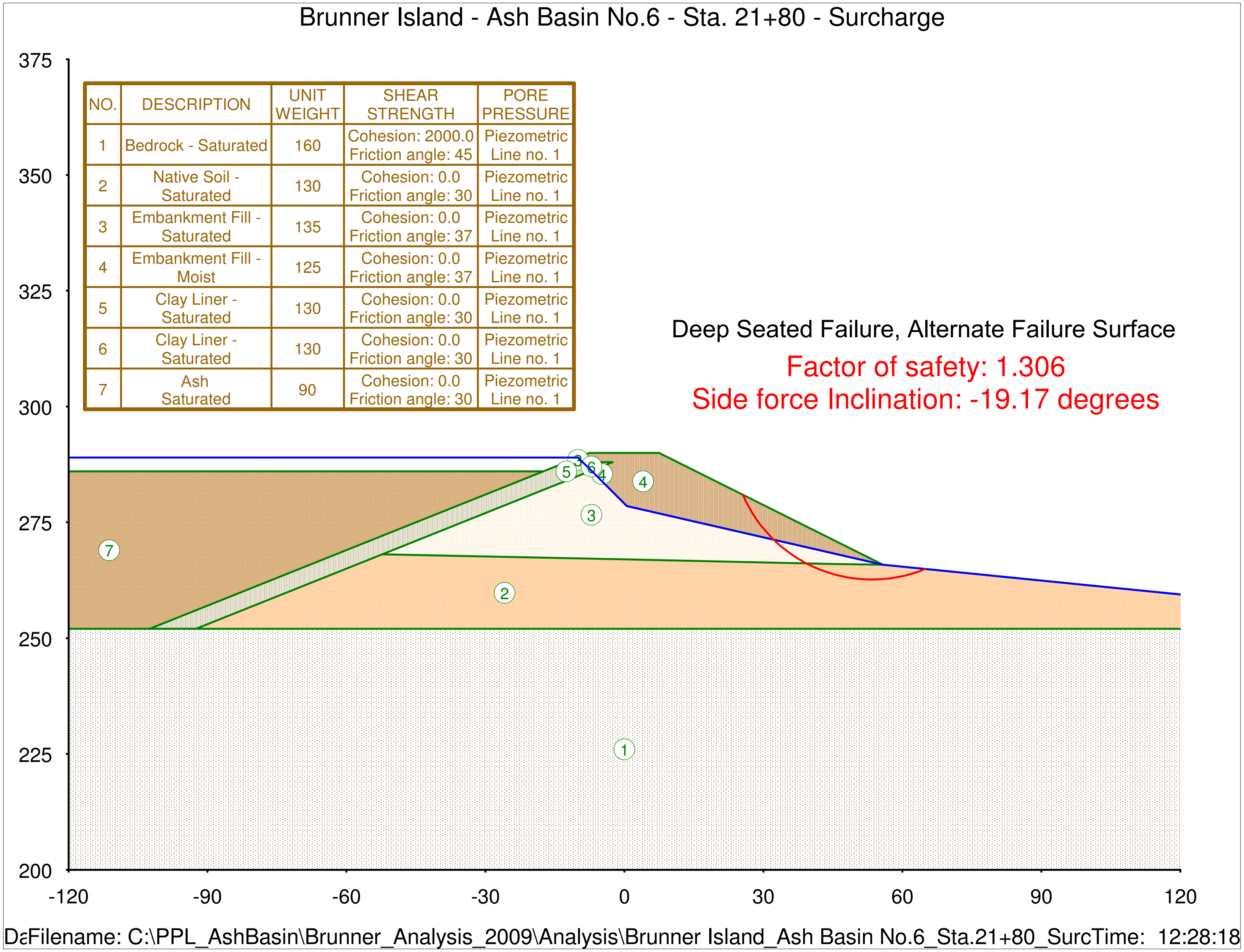
MAIN ANALYSES
NORMAL, SURCHARGE, 100-YEAR FLOOD, 500-YEAR FLOOD, AND EARTHQUAKE LOADING CONDITIONS



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
6	Clay Liner - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

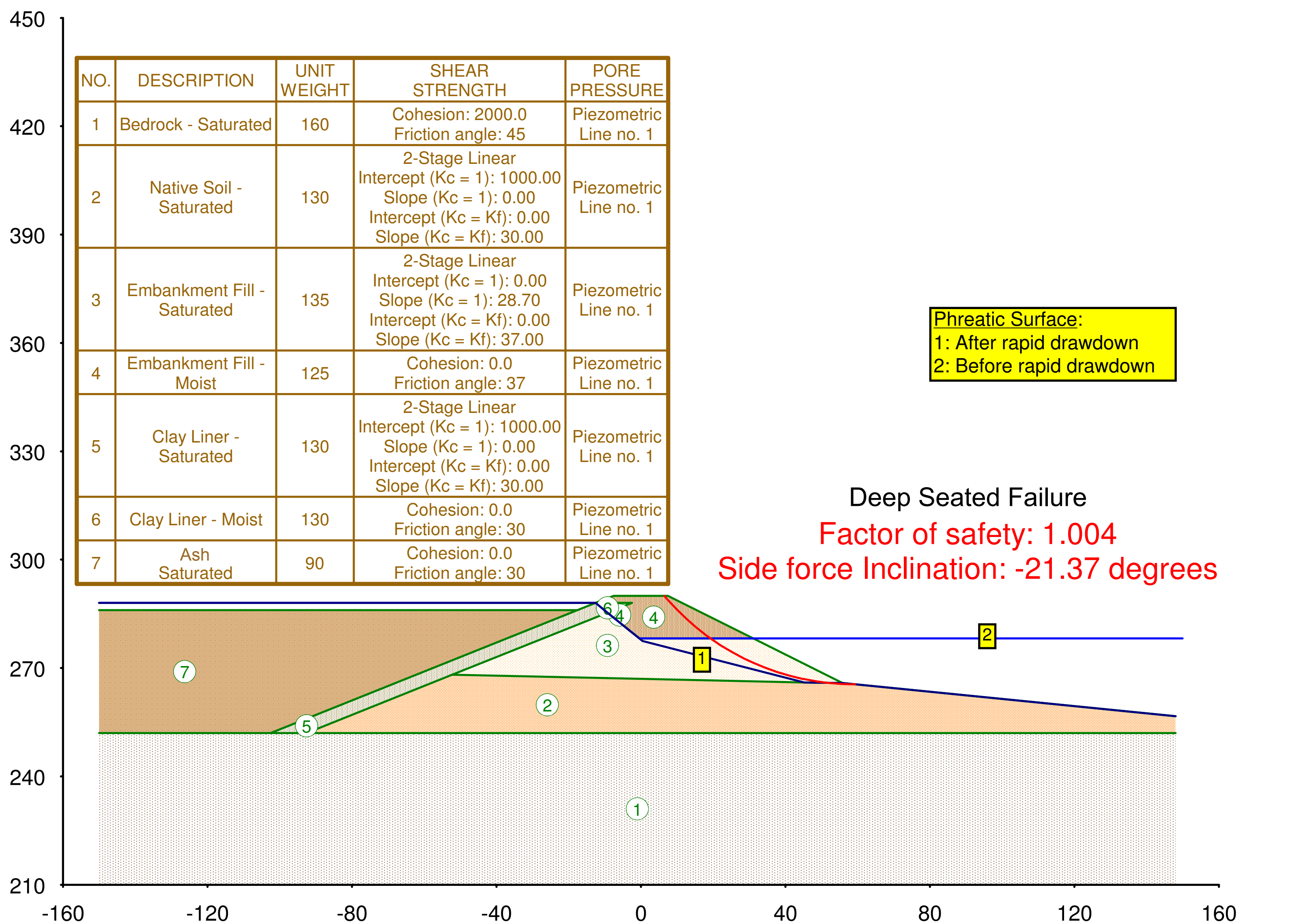


NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
6	Clay Liner - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
6	Clay Liner - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

Brunner Island - Ash Basin No.6 - Sta. 21+80 - Rapid Drawdown (100 yr Flood)

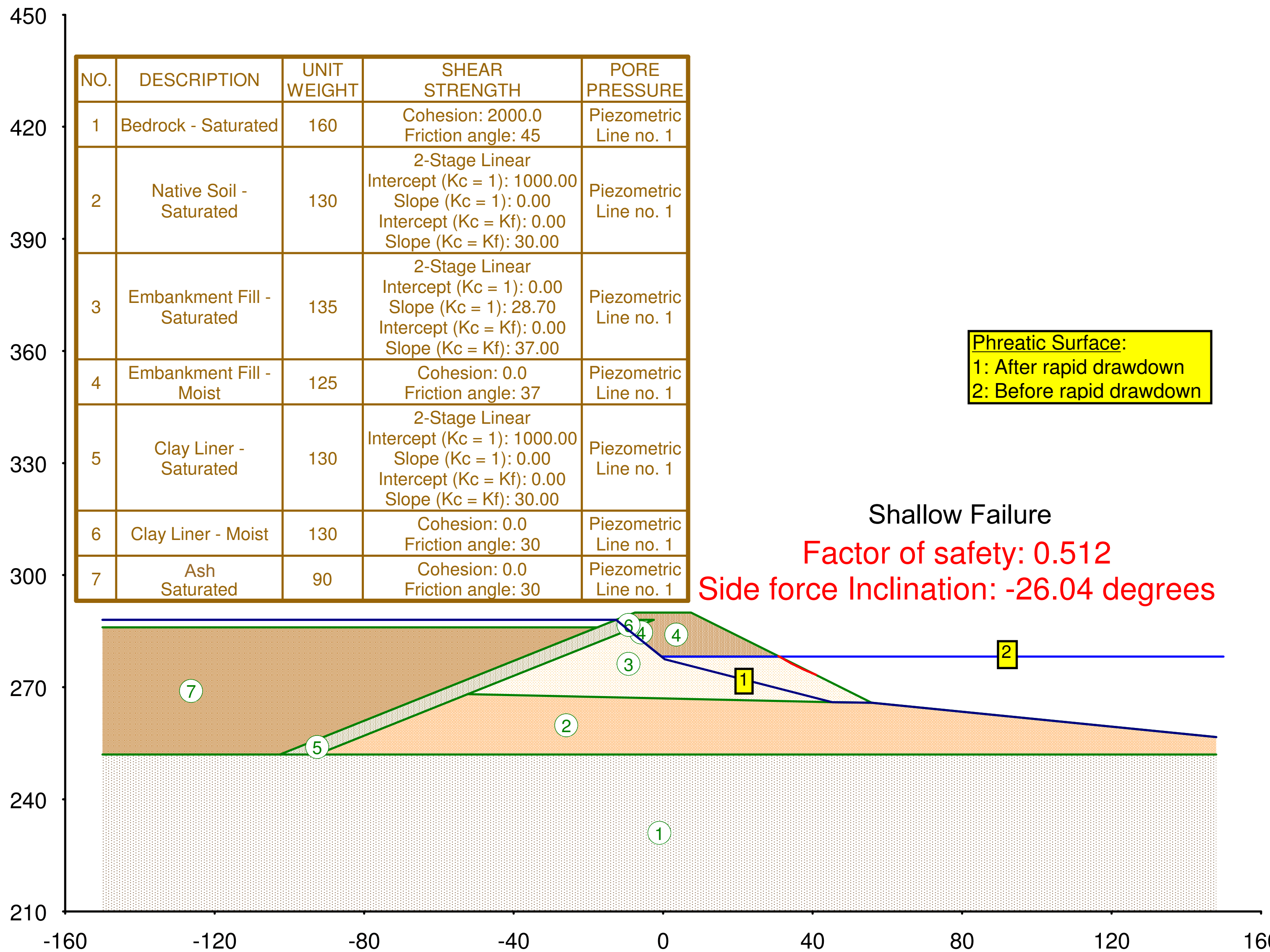


NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 28.70 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 37.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

Filename: C:\PPL_AshBasin\Brunner_Analysis_2009\Analysis\Brunner Island_Ash Basin No.6_Sta.21+80_Drawdown_1CTime: 17:45:33.0.UT4

Brunner Island - Ash Basin No.6 - Sta. 21+80 - Rapid Drawdown (100 yr Flood)

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 28.70 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 37.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1



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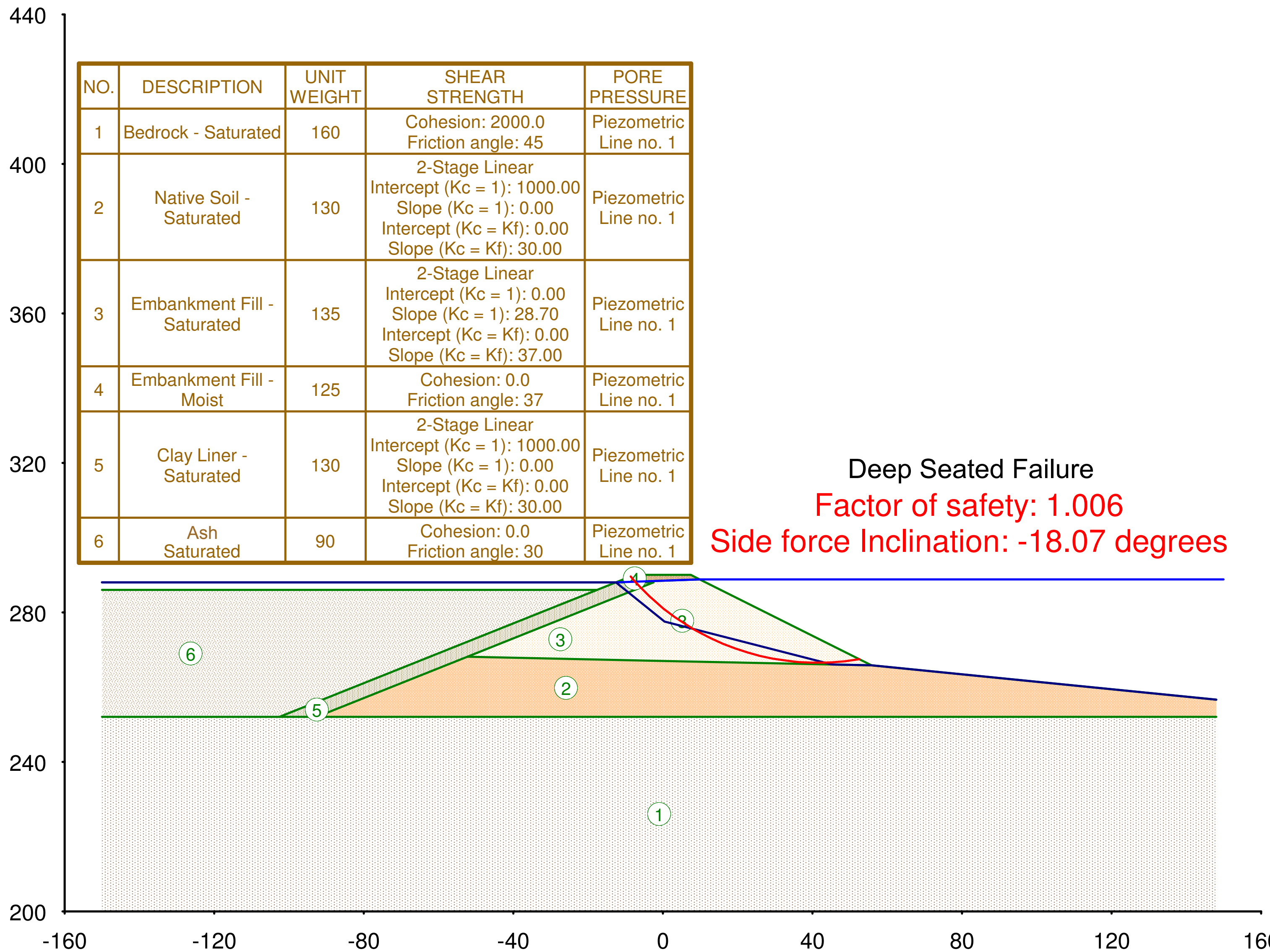
Brunner Island - Ash Basin No.6 - Sta. 21+80 - Rapid Drawdown (500 yr Flood) -



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 28.70 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 37.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Ash Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

lename: C:\PPL_AshBasin\Brunner_Analysis_2009\Analysis\Sensitivity_Flood\Brunner Island_Ash Basin No.6_Sta.21+80_DrawTime: 09:38:07pd_FS=1.0.UT4

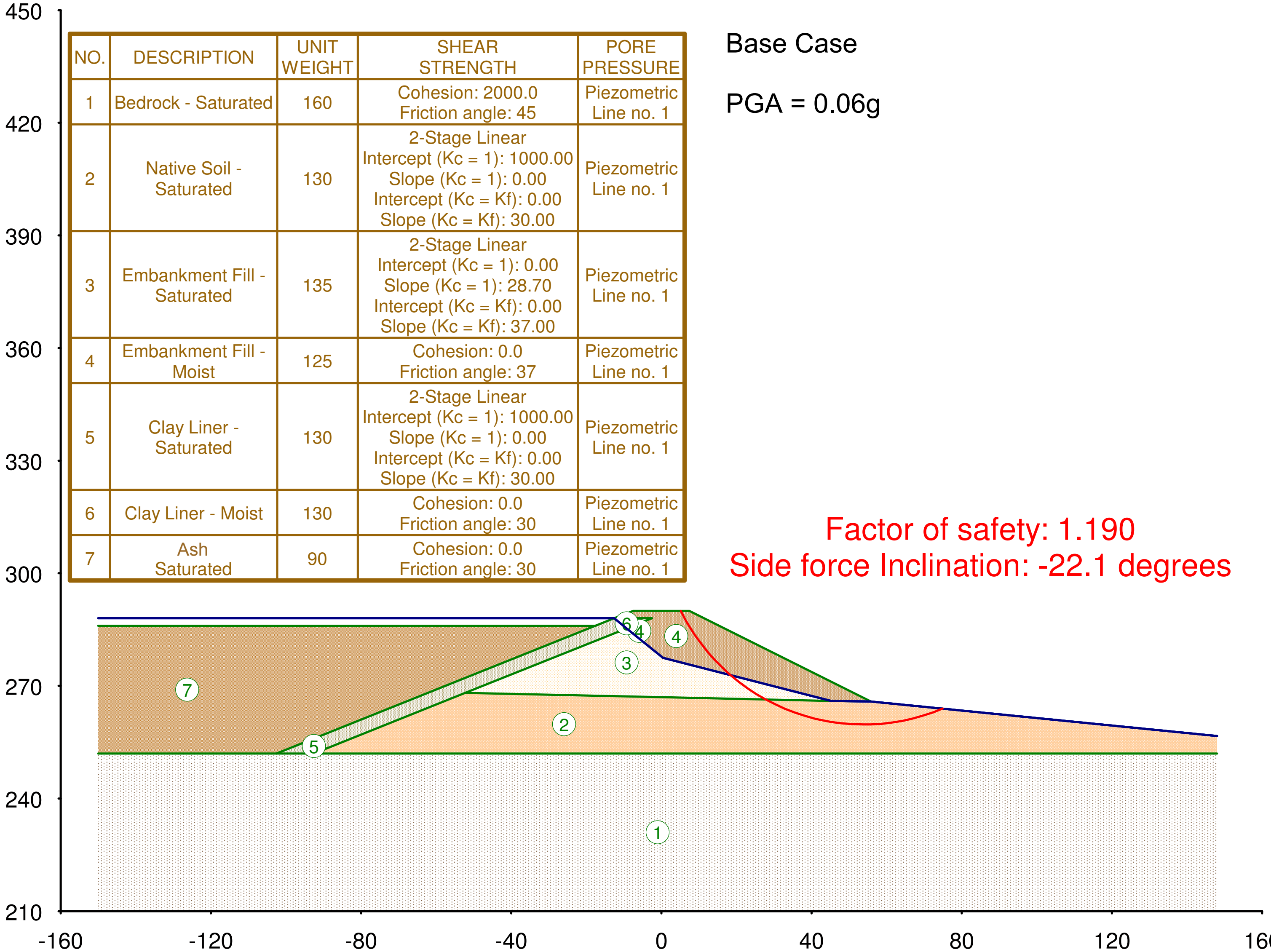
Brunner Island - Ash Basin No.6 - Sta. 21+80 - Pseudostatic Seismic

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 28.70 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 37.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

Base Case

PGA = 0.06g

Factor of safety: 1.190
Side force Inclination: -22.1 degrees



Filename: C:\PPL_AshBasin\Brunner_Analysis_2009\Analysis\Brunner Island_Ash Basin No.6_Sta.21+80_Pseudos Time: 13:05:12 4

SENSITIVITY ANALYSES
(DEMONSTRATE EFFECTS OF CHANGING FILL STRENGTH, FOUNDATION COHESION, AND EMBANKMENT PHREATIC SURFACE)

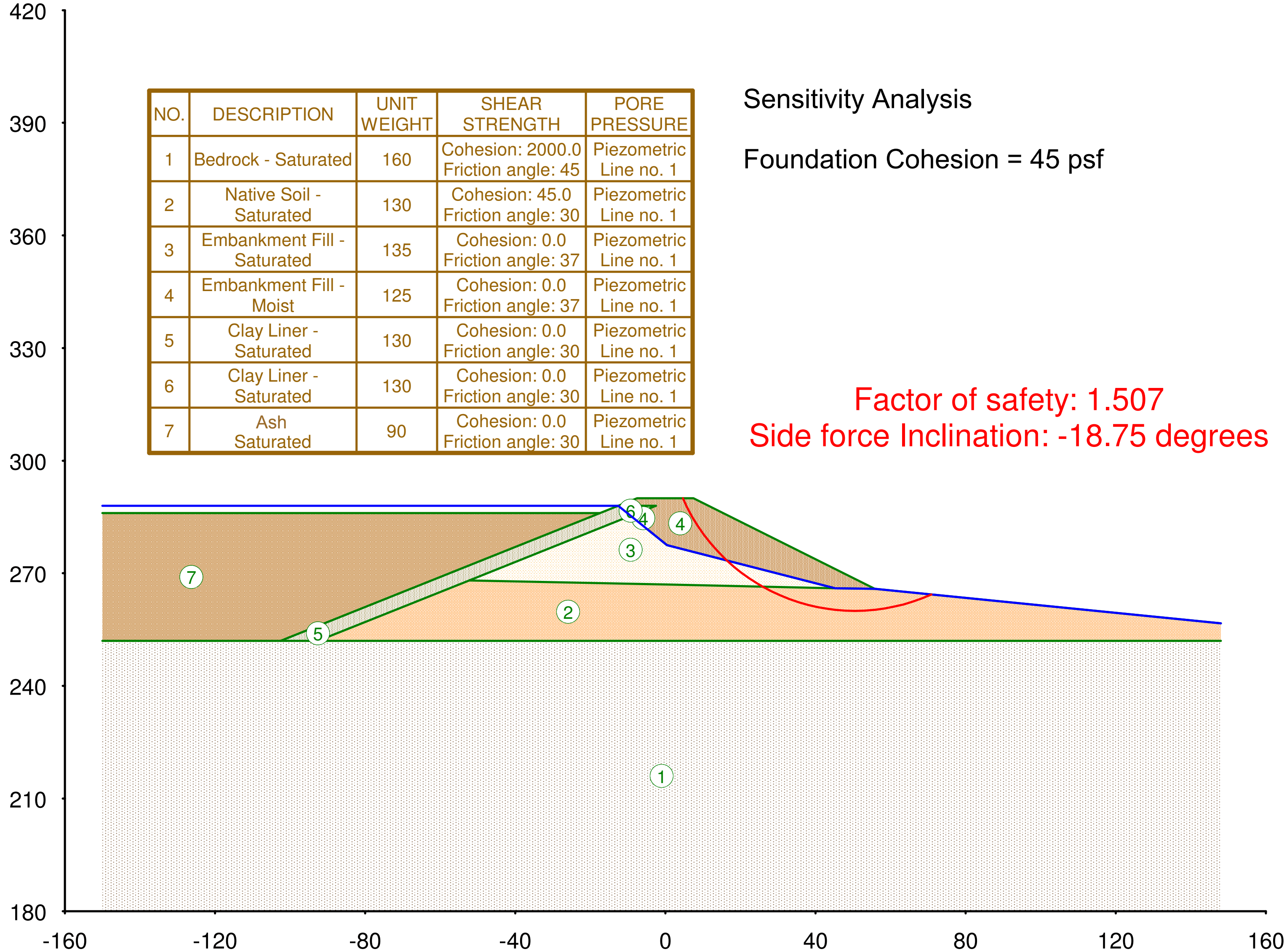
Brunner Island - Ash Basin No.6 - Sta. 21+80 - Normal

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	Cohesion: 45.0 Friction angle: 30	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
6	Clay Liner - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

Sensitivity Analysis

Foundation Cohesion = 45 psf

Factor of safety: 1.507
Side force Inclination: -18.75 degrees



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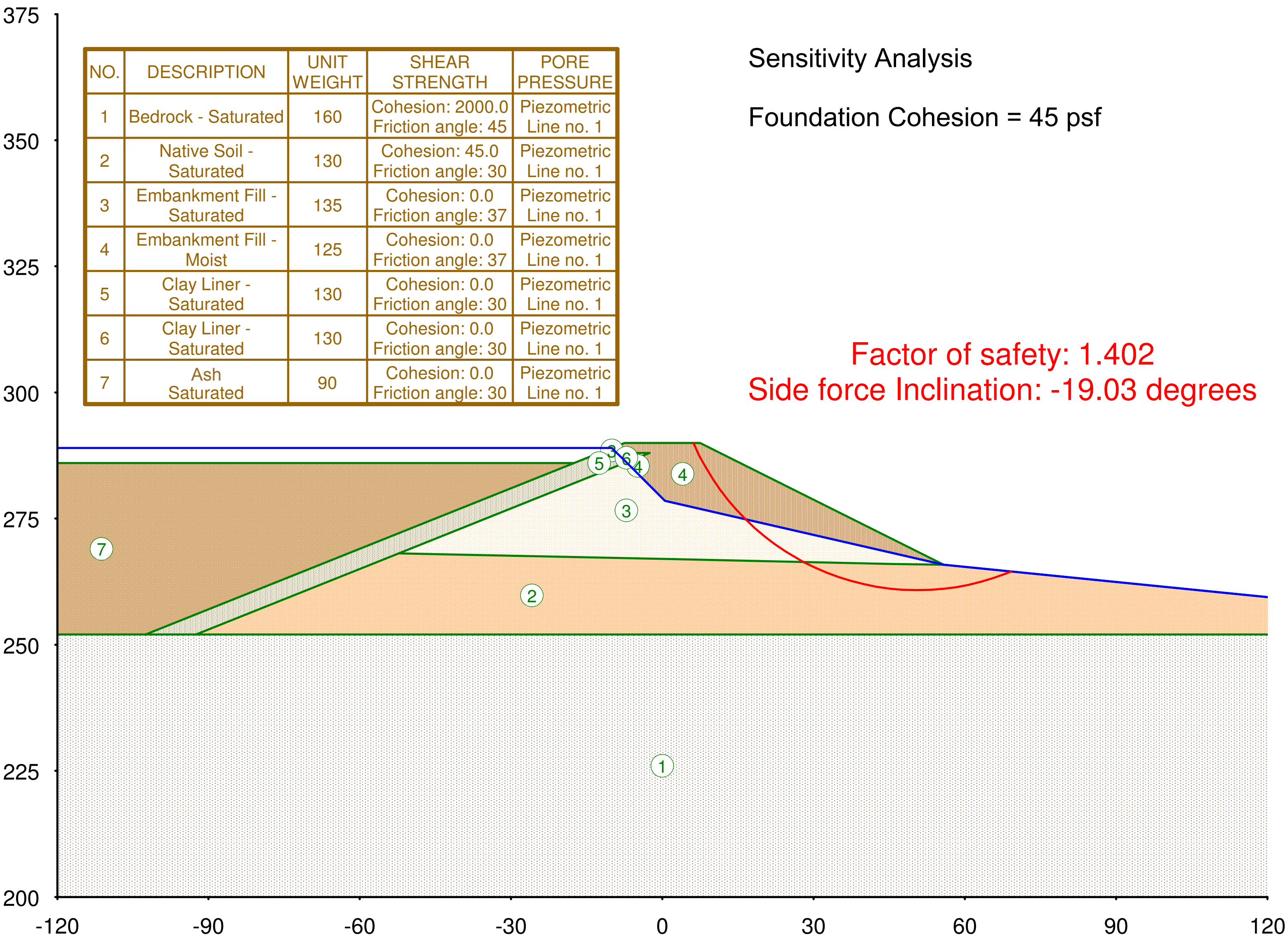
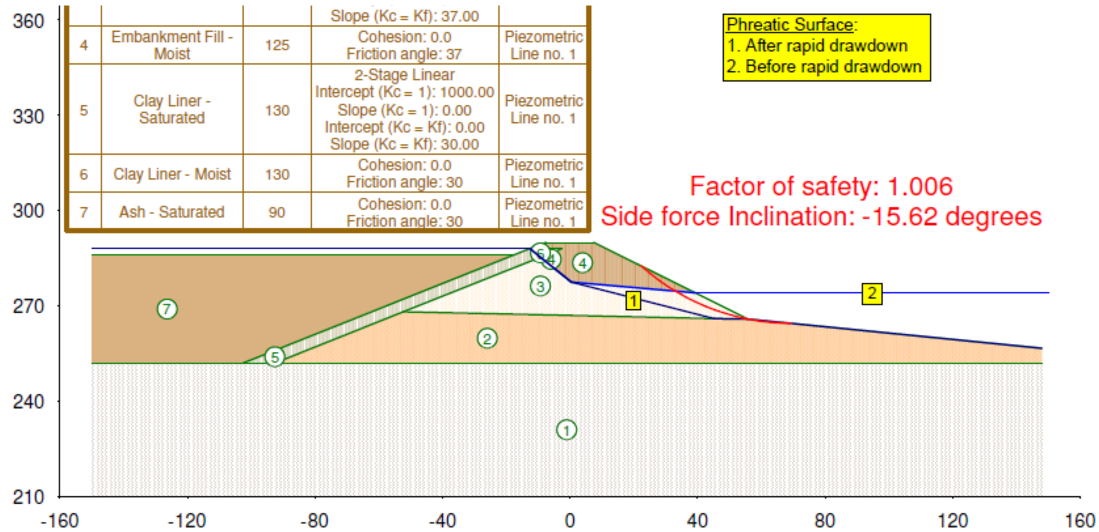
Brunner Island - Ash Basin No.6 - Sta. 21+80 - Surcharge



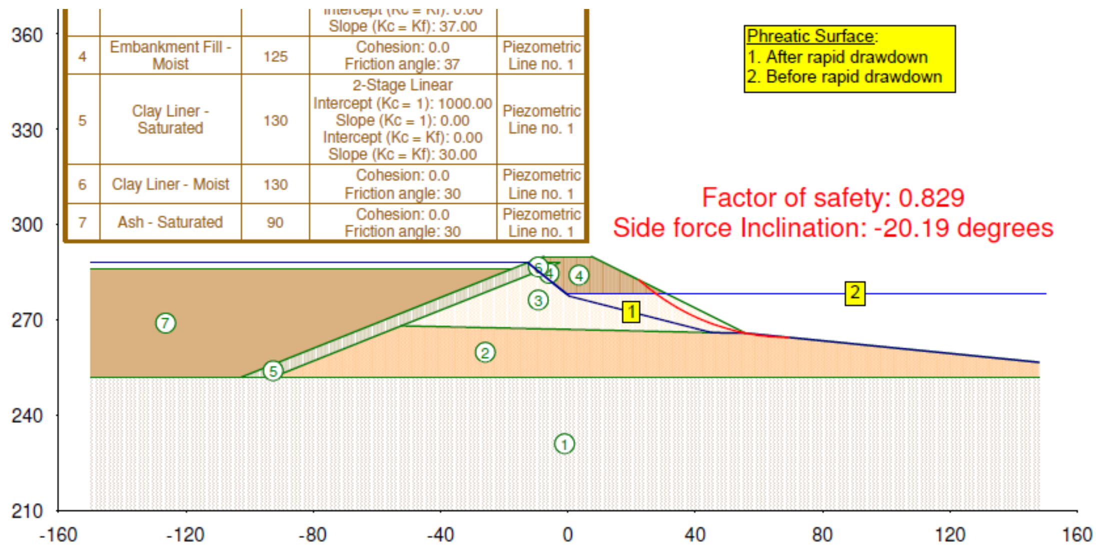
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	Cohesion: 45.0 Friction angle: 30	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
6	Clay Liner - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

Filename: C:\PPL_AshBasin\Brunner_Analysis_2009\Analysis\Brunner Island_Ash Basin No.6_Sta.21+80_SurchargTime: 14:15:374

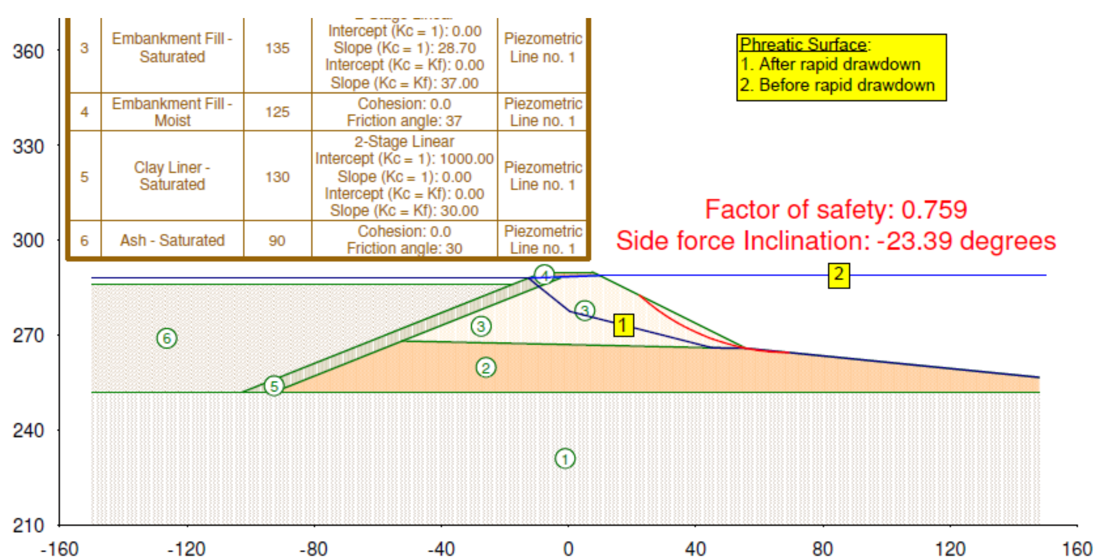
a) 10-year flood (FS = 1.0, as shown in initial analyses)



b) 100-year flood (using same circle with FS = 1.0 from 10-year flood)



c) 500-year flood (using same circle with FS = 1.0 from 10-year flood)



Brunner Island - Ash Basin No.6 - Sta. 21+80 - Rapid Drawdown (100 yr Flood)

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 27.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 34.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 34	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

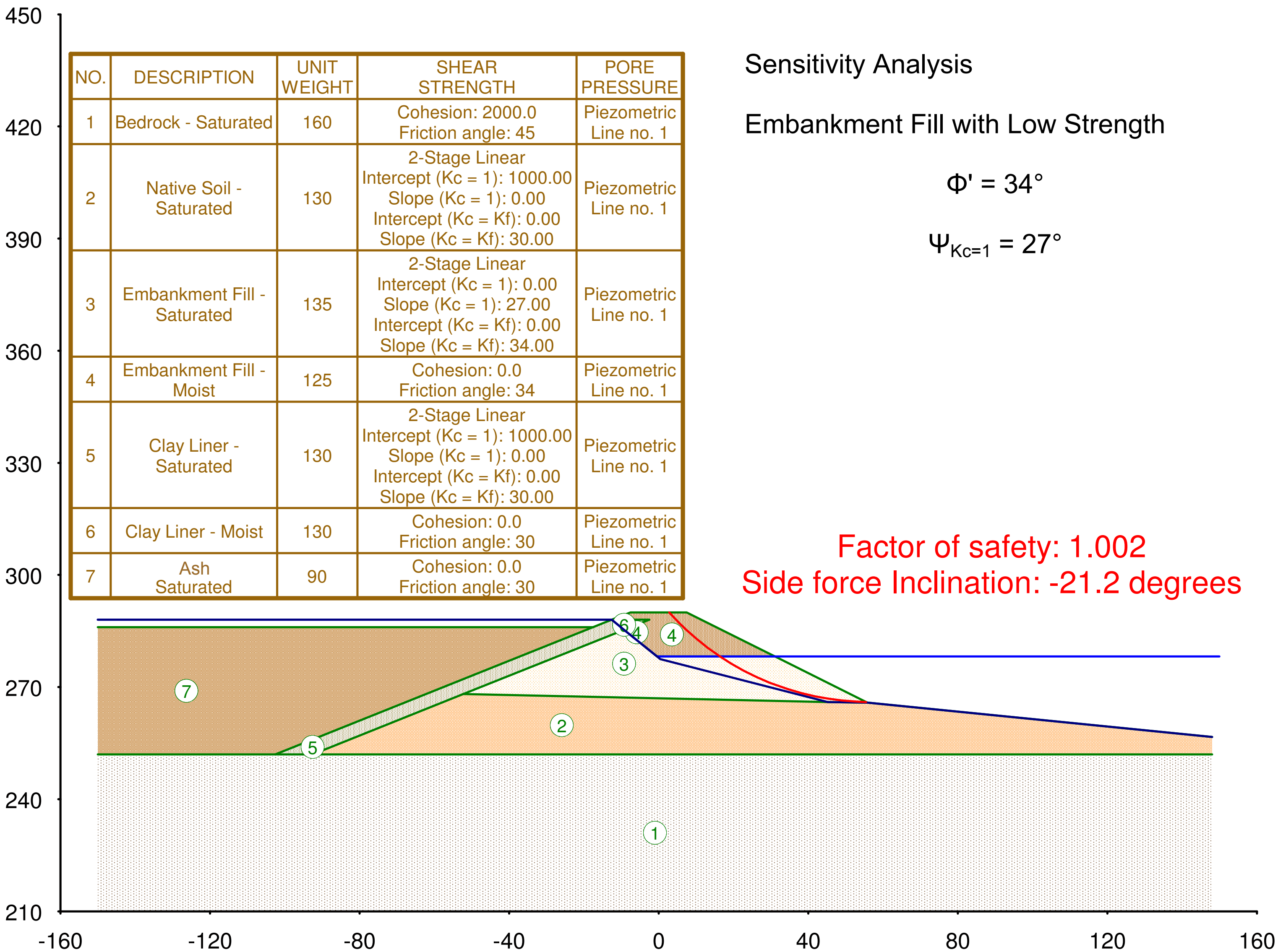
Sensitivity Analysis

Embankment Fill with Low Strength

$\Phi' = 34°$

$\Psi_{Kc=1} = 27°$

Factor of safety: 1.002
Side force Inclination: -21.2 degrees



PL_AshBasin\Brunner_Analysis_2009\Analysis\Sensitivity_Embankment Strength\Brunner Island_Ash Basin No.6_Sta.21+80_DiTime: 17:16:16Flood_Emb Low_FS

Brunner Island - Ash Basin No.6 - Sta. 21+80 - Rapid Drawdown (100 yr Flood)

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 288.00 Slope (Kc = 1): 28.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 37.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

Sensitivity Analysis

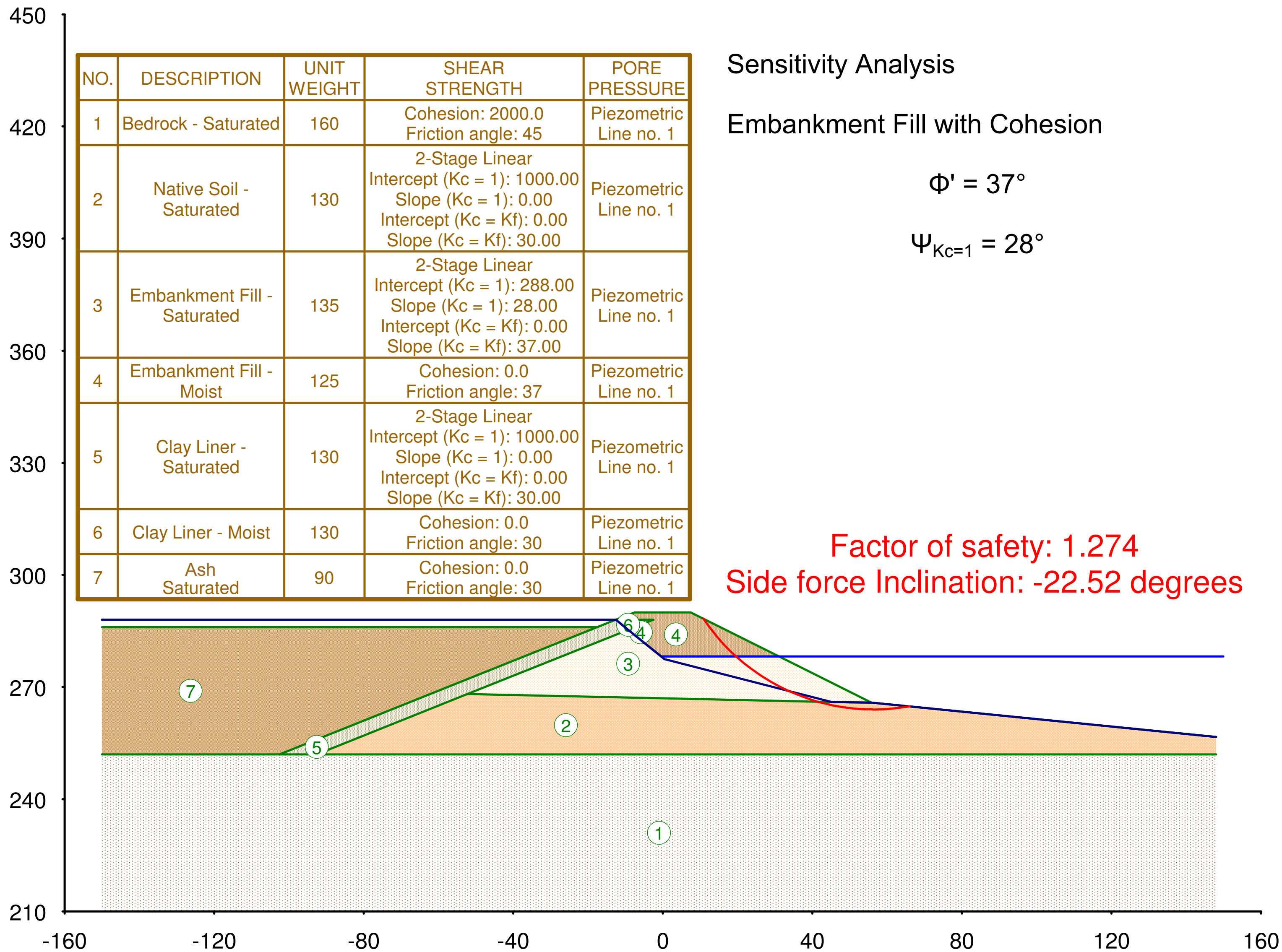
Embankment Fill with Cohesion

$\Phi' = 37°$

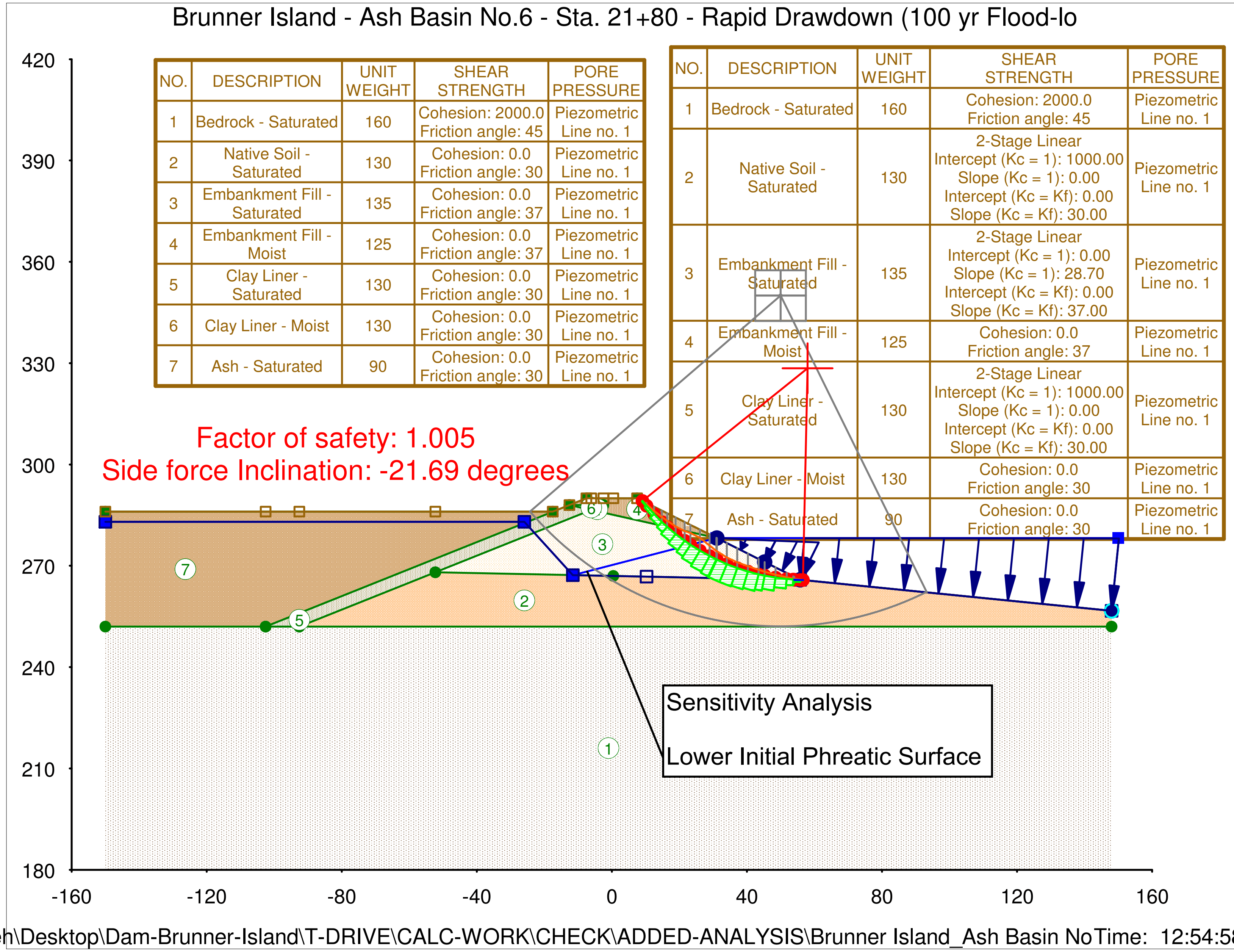
$\Psi_{Kc=1} = 28°$

Factor of safety: 1.274

Side force Inclination: -22.52 degrees



PL_AshBasin\Brunner_Analysis_2009\Analysis\Sensitivity_Embankment Strength\Brunner Island_Ash Basin No.6_Sta.21+80_DiTime: 16:46:09Flood_Emb High_F



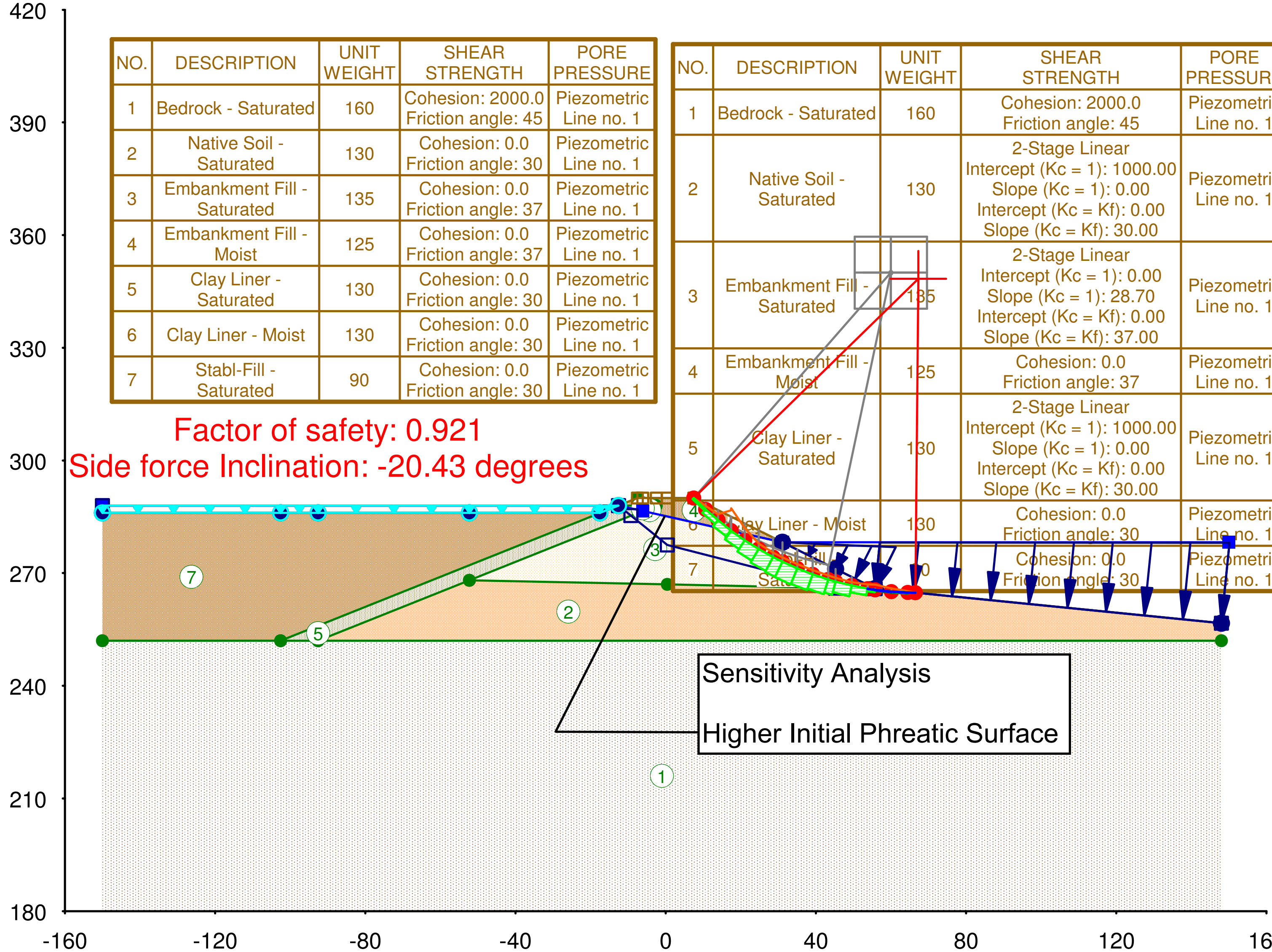
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash - Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 28.70 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 37.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash - Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

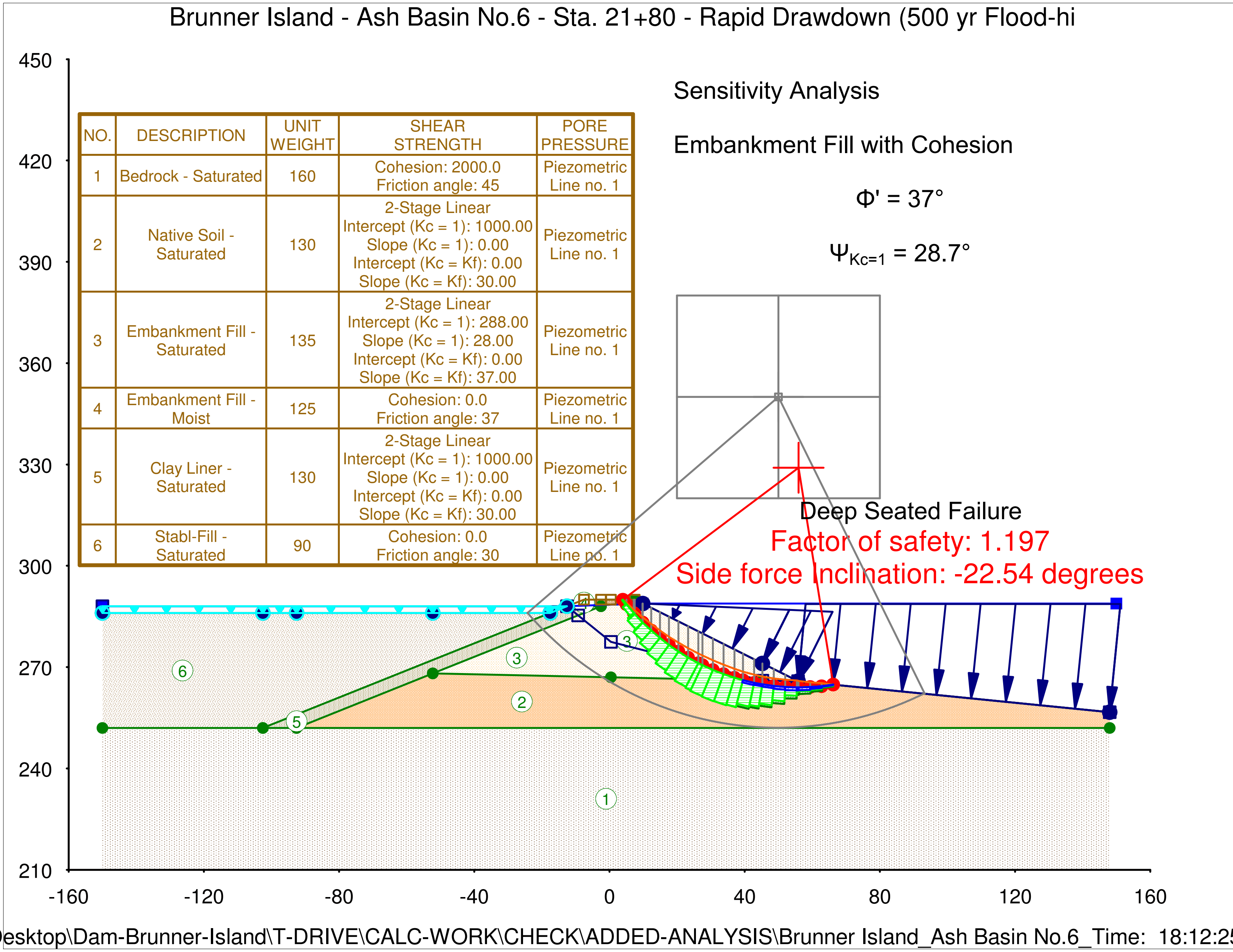
Brunner Island - Ash Basin No.6 - Sta. 21+80 - Rapid Drawdown (100 yr Flood)

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Stabl-Fill - Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 28.70 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 37.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Stabl-Fill - Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

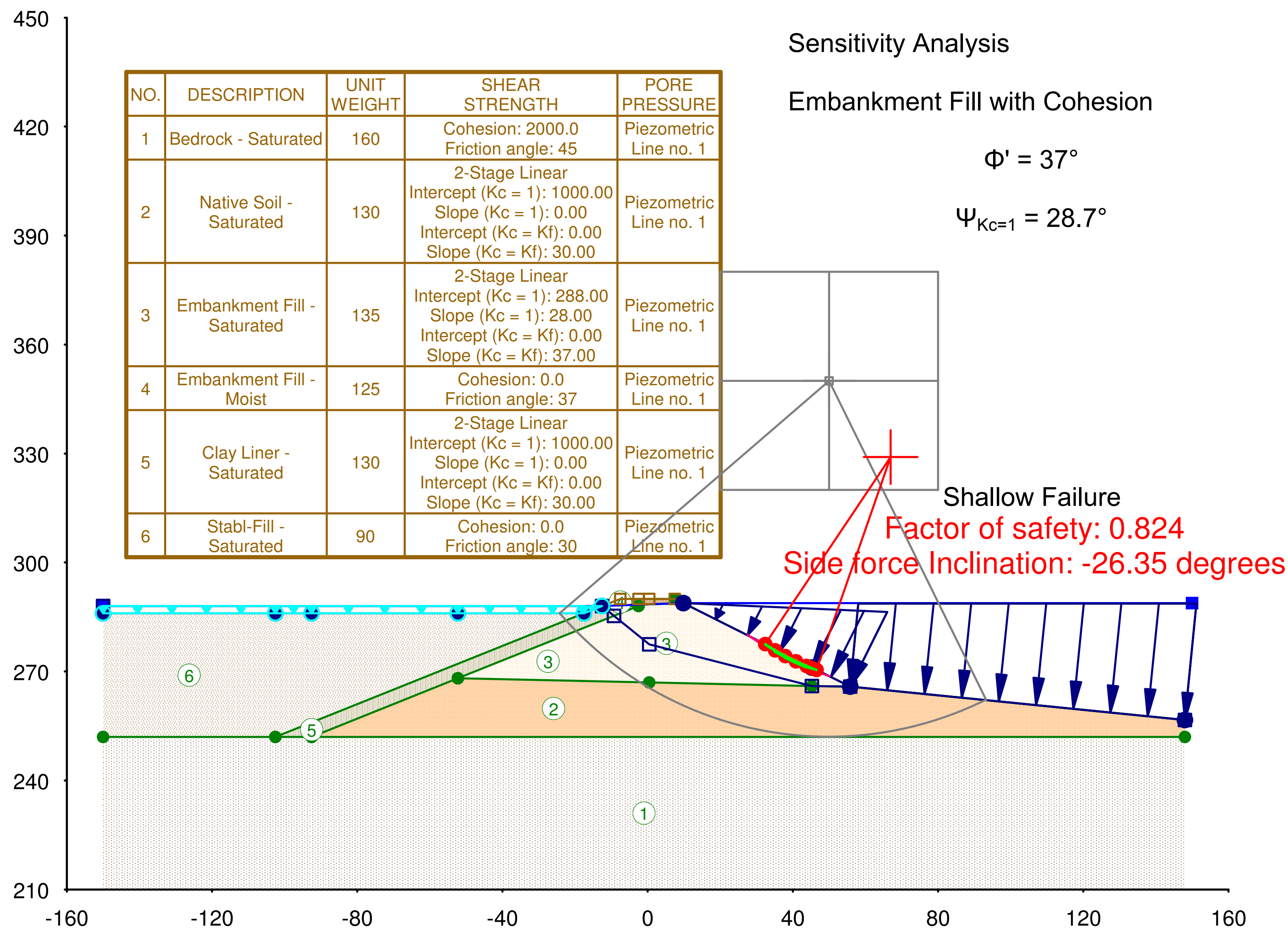


abedzadeh\Desktop\Dam-Brunner-Island\T-DRIVE\CALC-WORK\CHECK\ADDED-ANALYSIS\Brunner Island_Ash Basin No.6_S Time: 14:31:30 down_100yrFlood_



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 288.00 Slope (Kc = 1): 28.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 37.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Stabl-Fill - Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

Brunner Island - Ash Basin No.6 - Sta. 21+80 - Rapid Drawdown (500 yr Flood-hi



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 288.00 Slope (Kc = 1): 28.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 37.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Stabl-Fill - Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

gs\fabedzadeh\Desktop\Dam-Brunner-Island\T-DRIVE\CALC-WORK\CHECK\ADDED-ANALYSIS\Brunner Island_Ash Basin NcTime: 18:09:43Drawdown_500yrFlo

Client: ***Pennsylvania Power & Light***
Project: ***Brunner Ash Basin Slope Stability Analysis***
Subject: ***Slope Stability - Sensitivity Analysis - Closure, Dewatering & Flood***

<u>Load Case</u>: Rapid Drawdown

Material Types	γ_{moist} (pcf)	γ_{sat} (pcf)	c' (pcf)	ϕ ' (pcf)	$d_{Kc=1}$ (pcf)	$\psi_{Kc=1}$ (pcf)
Embankment Fill	125	135	0	37.0	0	28.7
Native Soil	---	130	0	30.0	1000	0
Clay Liner	130	130	0	30.0	1000	0
Ash	90	90	0	30.0	---	---

<u>Note</u>: $d_{Kc=Kf}$ = c' $\psi_{Kc=Kf}$ = ϕ '

<u>Factor of Safety Comparison</u>
(Use slip surface with FS ≈ 1.0 for 10 yr flood rapid drawdown load case as reference)

Ash Basin Closure	Ash Basin Dewatering	Flood	Phreatic Surface	FS
No	No	100 yr	Original	0.83
No	No	500 yr	Original	0.76
Yes	No	100 yr	High	0.83
Yes	No	500 yr	High	0.76
Yes	Yes	100 yr	Low	0.83
Yes	Yes	500 yr	Low	0.76

<u>Slip Surface Extend Comparison</u>
(Use slip surfaces with FS ≈ 1.0 for for comparison)

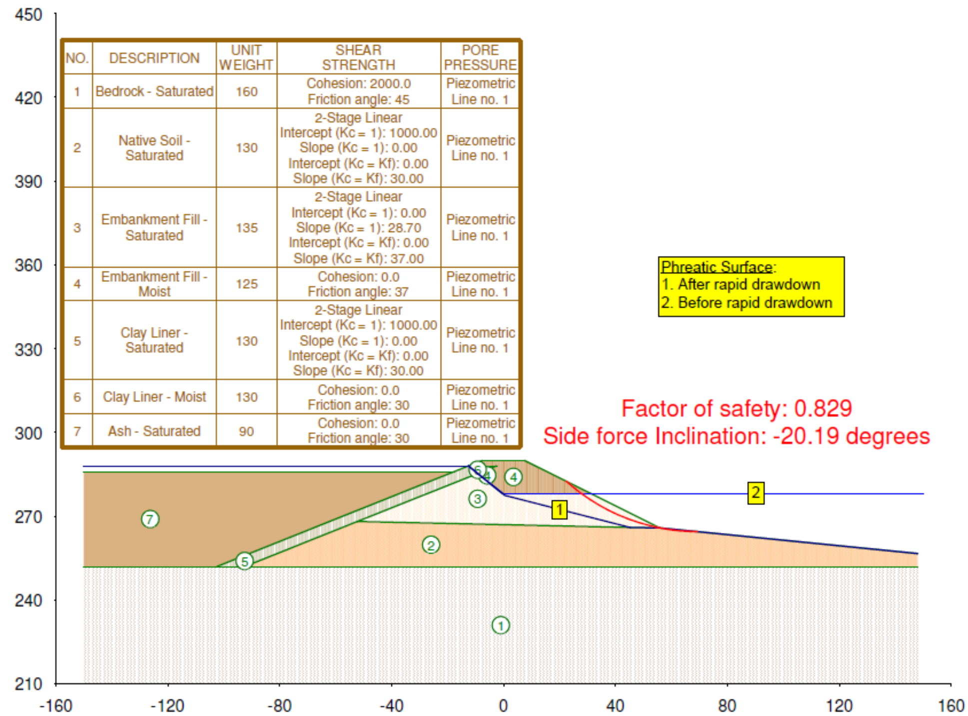
Ash Basin Closure	Ash Basin Dewatering	Flood	Phreatic Surface	Slip Surface Extend
No	No	100 yr	Original	Crest (width: 1.0 ft), slope (max height: 7 ft), and foundation (surficial)
No	No	500 yr	Original	Upstream slope (Width: 1 ft), crest (All, width: 15 ft), and downstream slope (Max height: 14.5 ft)
Yes	No	100 yr	High	Crest (width: 0.5 ft), slope (max height: 7 ft), and foundation (surficial)
Yes	No	500 yr	High	Upstream slope (Width: 0.5 ft), crest (All, width: 15 ft), and downstream slope (Max height: 13.5 ft)
Yes	Yes	100 yr	Low	Slope (max height: 7 ft), and foundation (surficial)
Yes	Yes	500 yr	Low	Crest (All, width: 14.5 ft), and downstream slope (Max height: 13.5 ft)

High: Ash basin water table is assumed at ash basin surface (Elev. 286.0)
Low: Ash basin water table is assumed near native ground surface (Elev. 268.3)

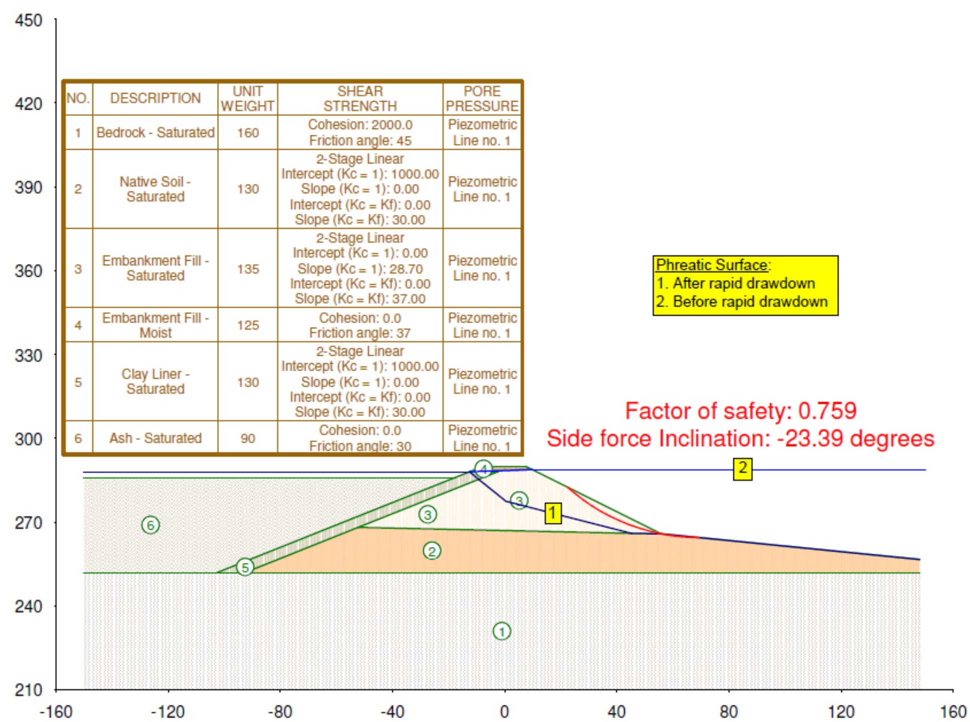
<u>Conclusion</u>
1. Dewatering of the ash basin will not improve the stability of the embankment under rapid drawdown loading.
2. Rapid drawdown stability is governed by the flood level which controls the downstream slope phreatic surface.

Factor of Safety Comparison

(Use slip surface with FS ≈ 1.0 for 10 yr flood rapid drawdown load case as reference)



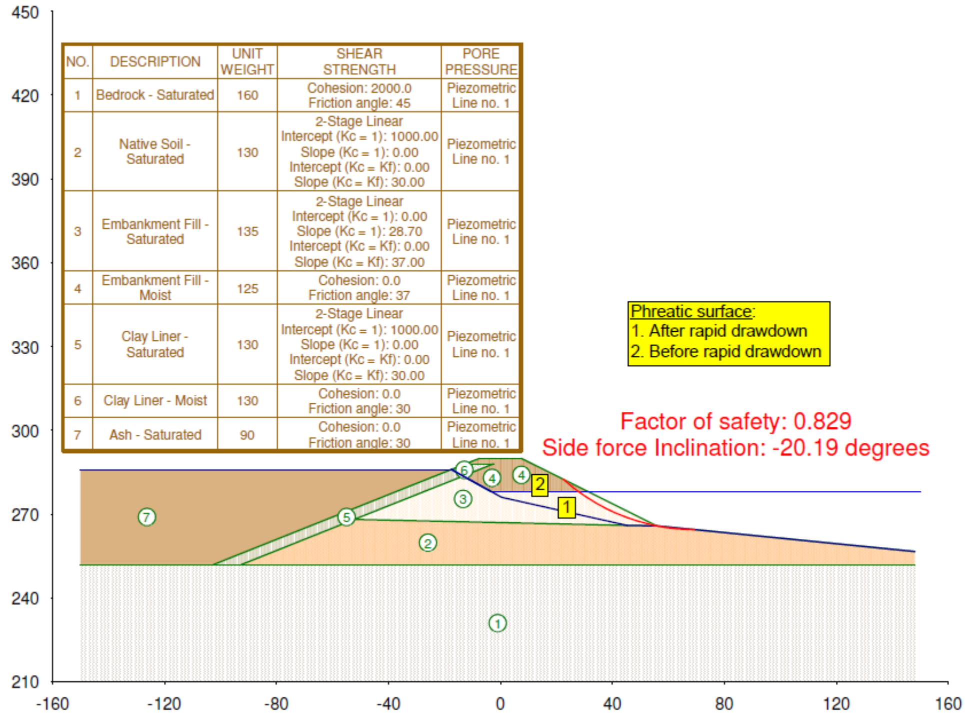
Existing condition – 100 yr flood



Existing condition – 500 yr flood

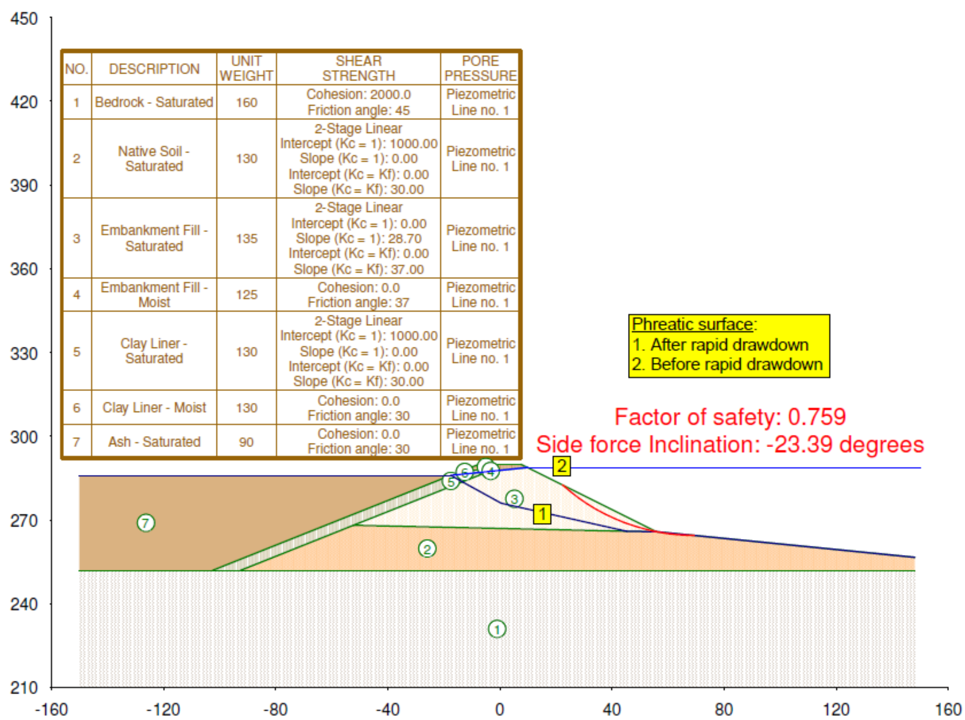
Factor of Safety Comparison

(Use slip surface with FS ≈ 1.0 for 10 yr flood rapid drawdown load case as reference)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 28.70 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 37.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash - Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

After basin closure without dewatering – 100 yr flood

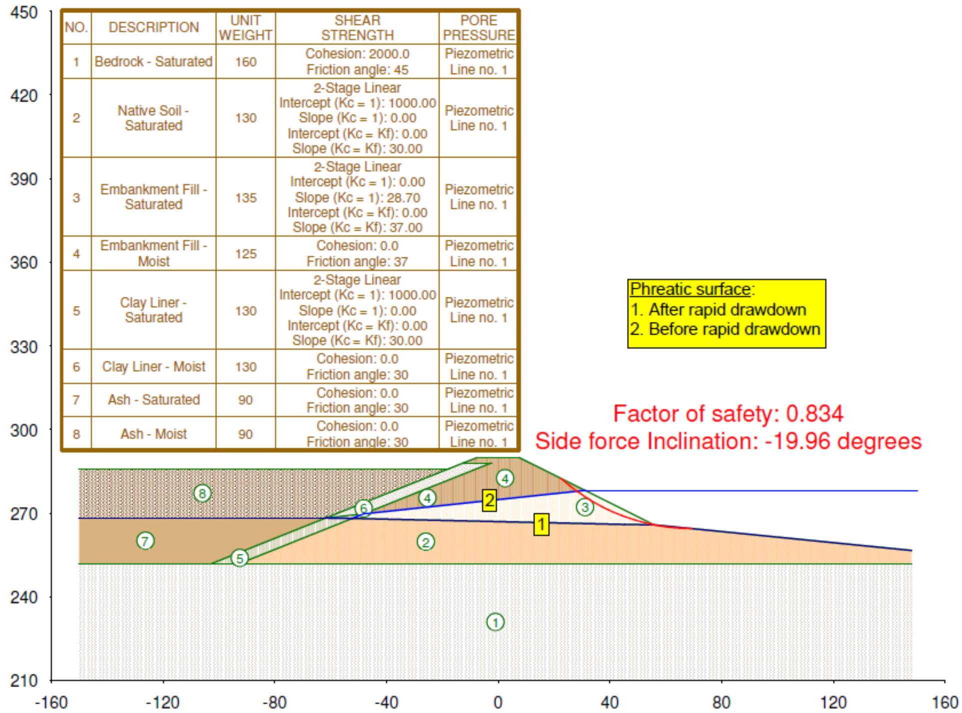


NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 28.70 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 37.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash - Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

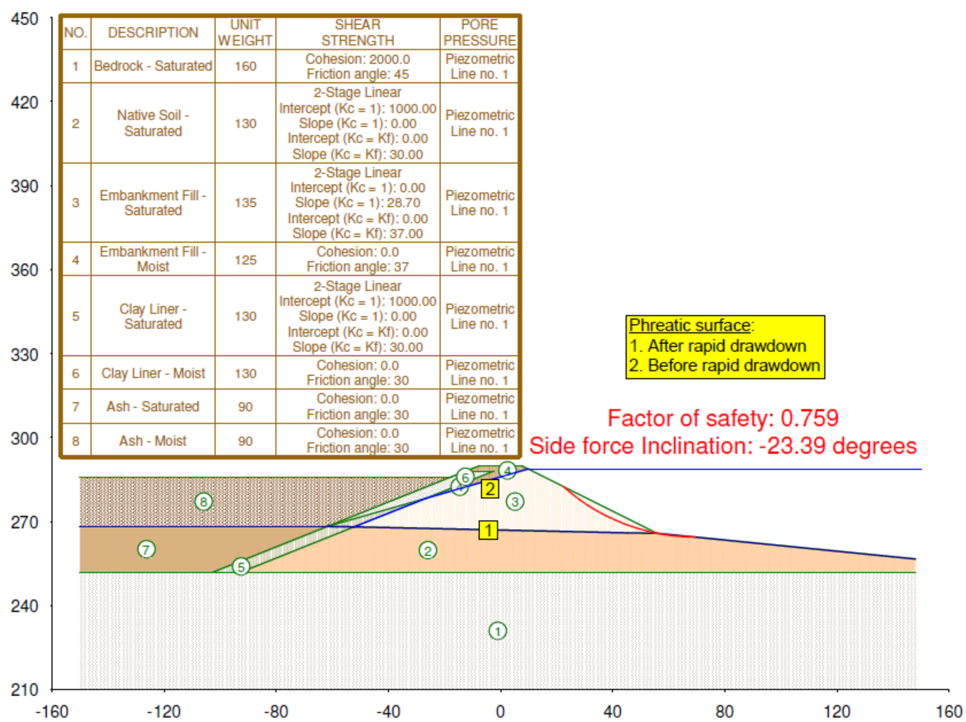
After basin closure without dewatering – 500 yr flood

Factor of Safety Comparison

(Use slip surface with FS ≈ 1.0 for 10 yr flood rapid drawdown load case as reference)

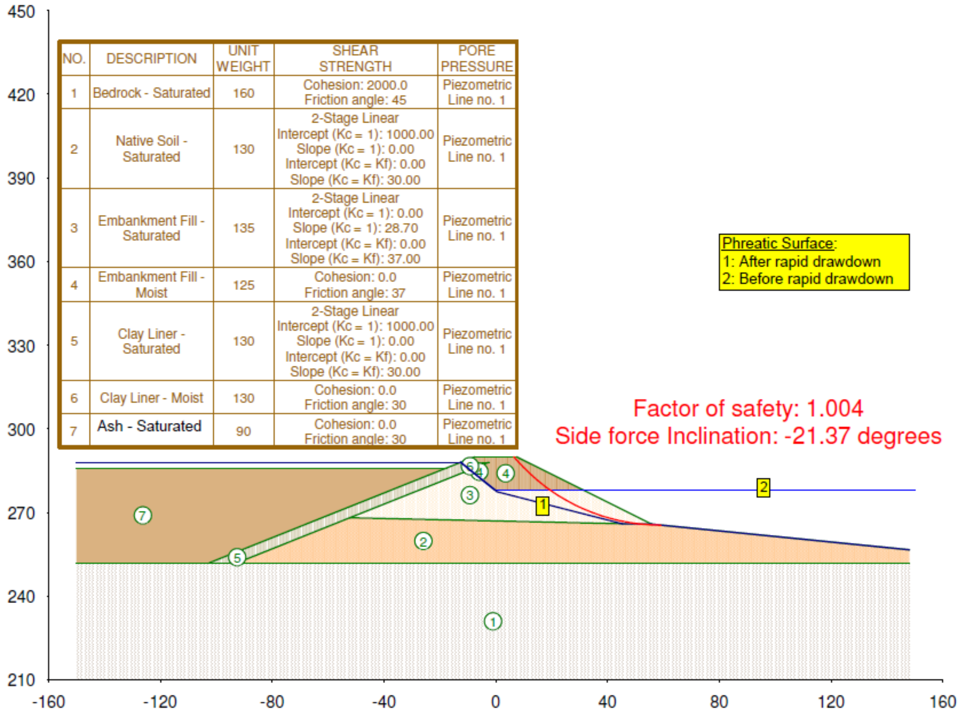


After basin closure with dewatering – 100 yr flood

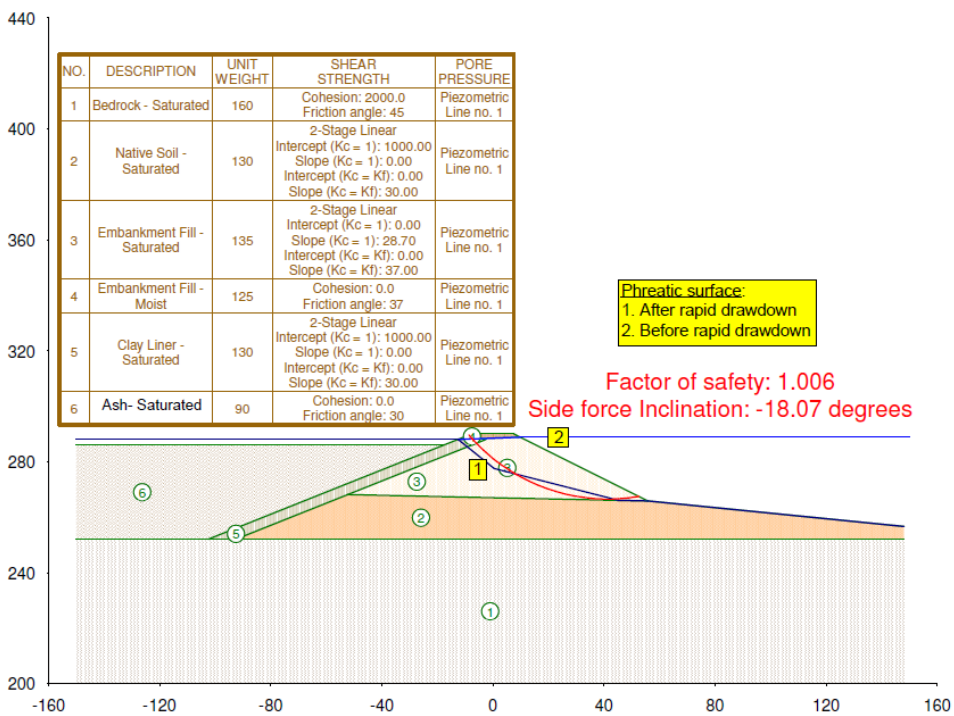


After basin closure with dewatering – 500 yr flood

Slip Surface Extend Comparison
(Use slip surfaces with FS ≈ 1.0 for comparison)

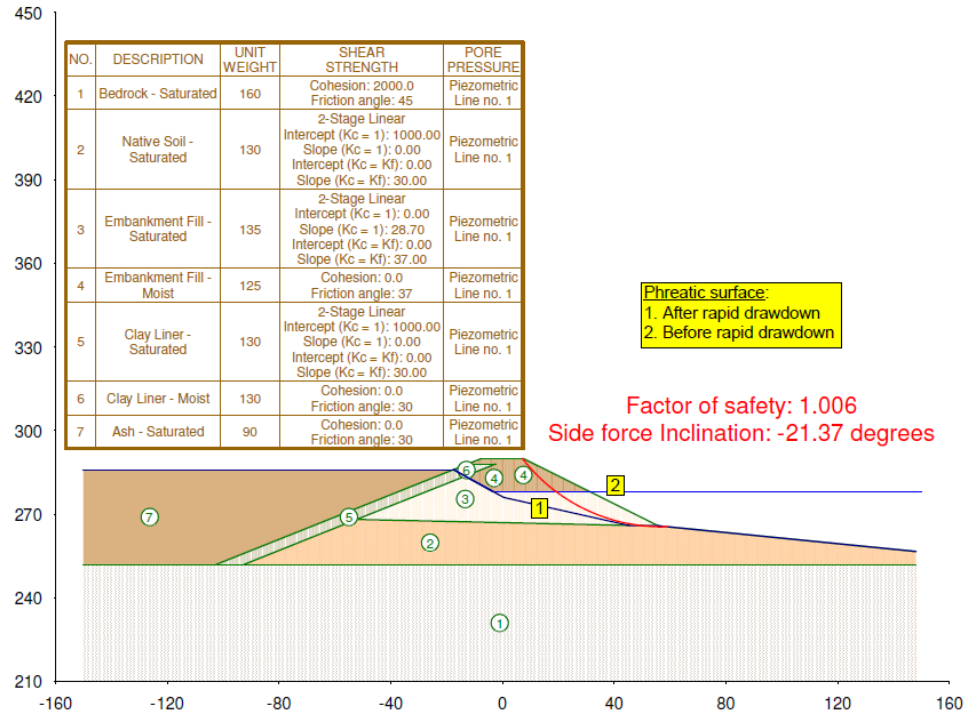


Existing condition – 100 yr flood



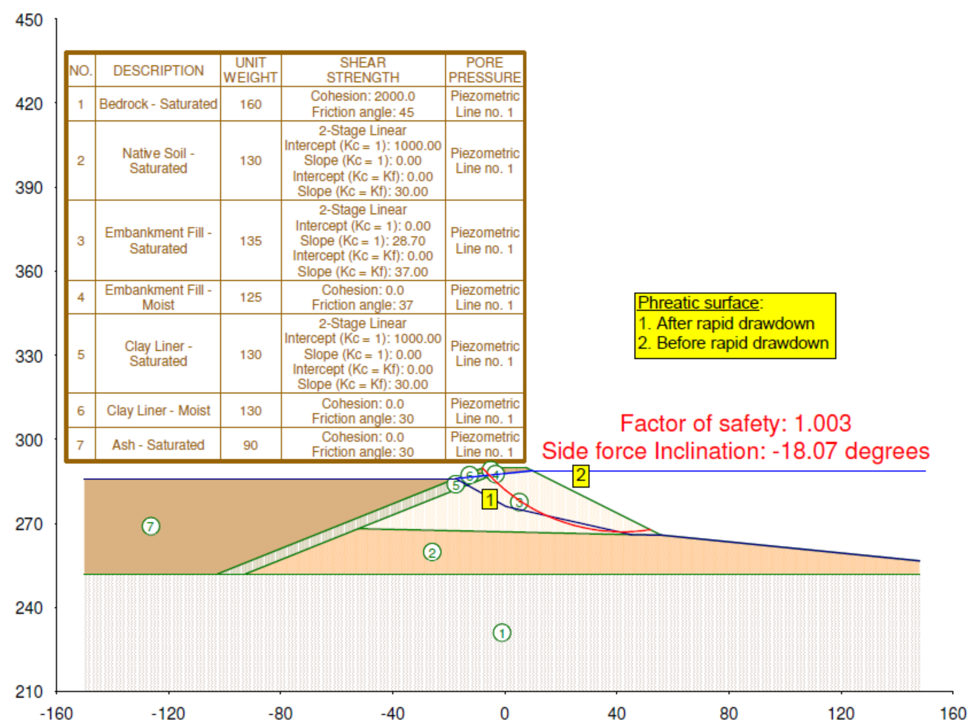
Existing condition – 500 yr flood

Slip Surface Extend Comparison
(Use slip surfaces with FS ≈ 1.0 for comparison)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 28.70 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 37.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash - Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

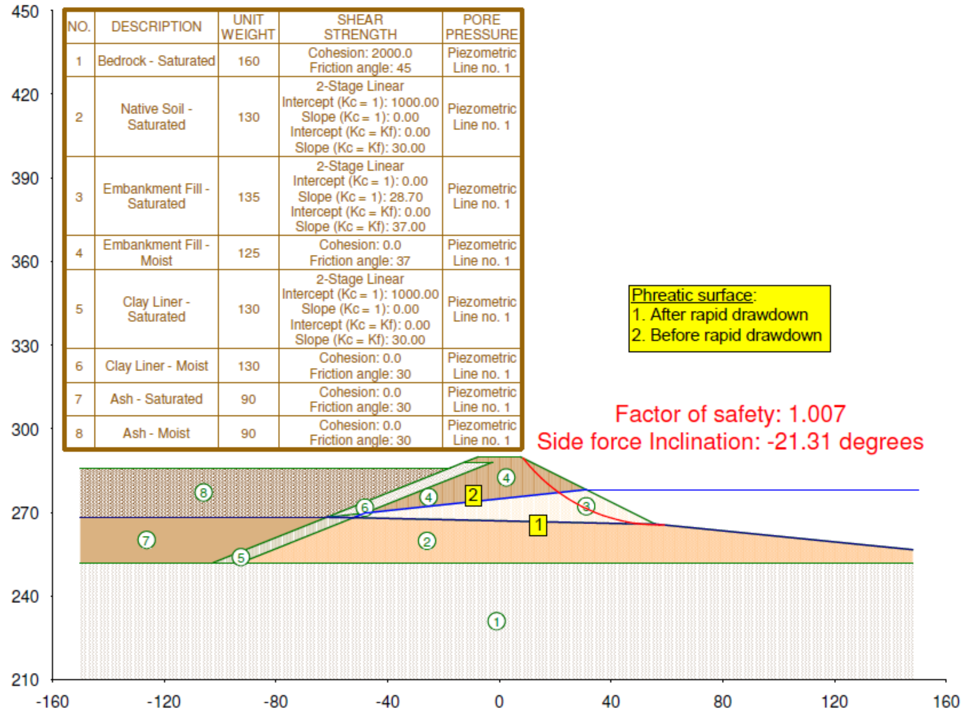
After basin closure without dewatering – 100 yr flood



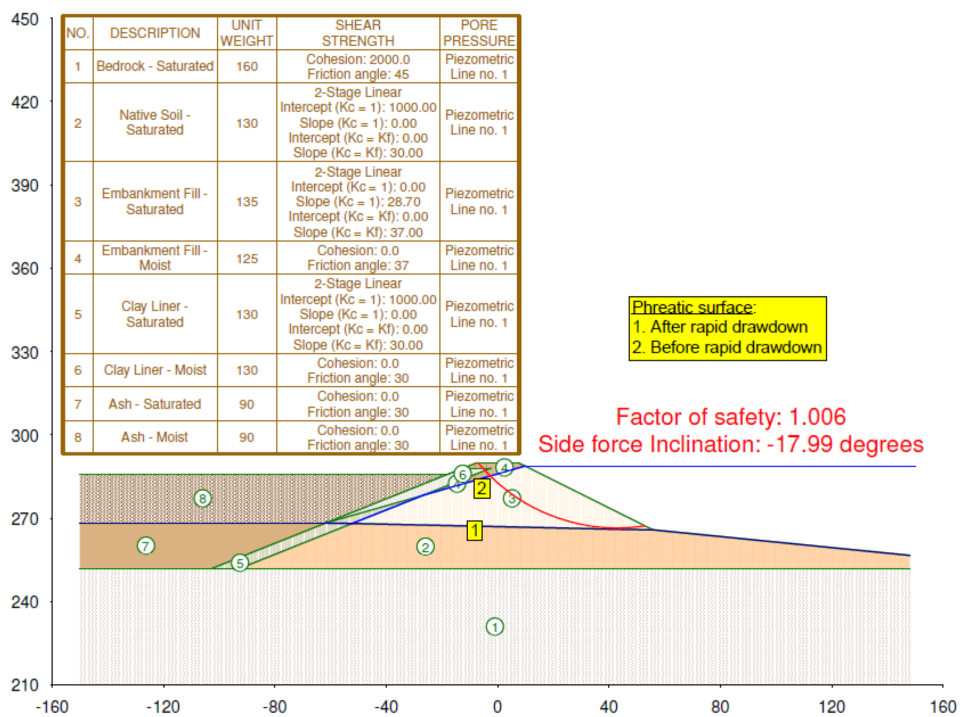
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 28.70 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 37.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash - Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

After basin closure without dewatering – 500 yr flood

Slip Surface Extend Comparison
(Use slip surfaces with FS ≈ 1.0 for comparison)



After basin closure with dewatering – 100 yr flood



After basin closure with dewatering – 500 yr flood

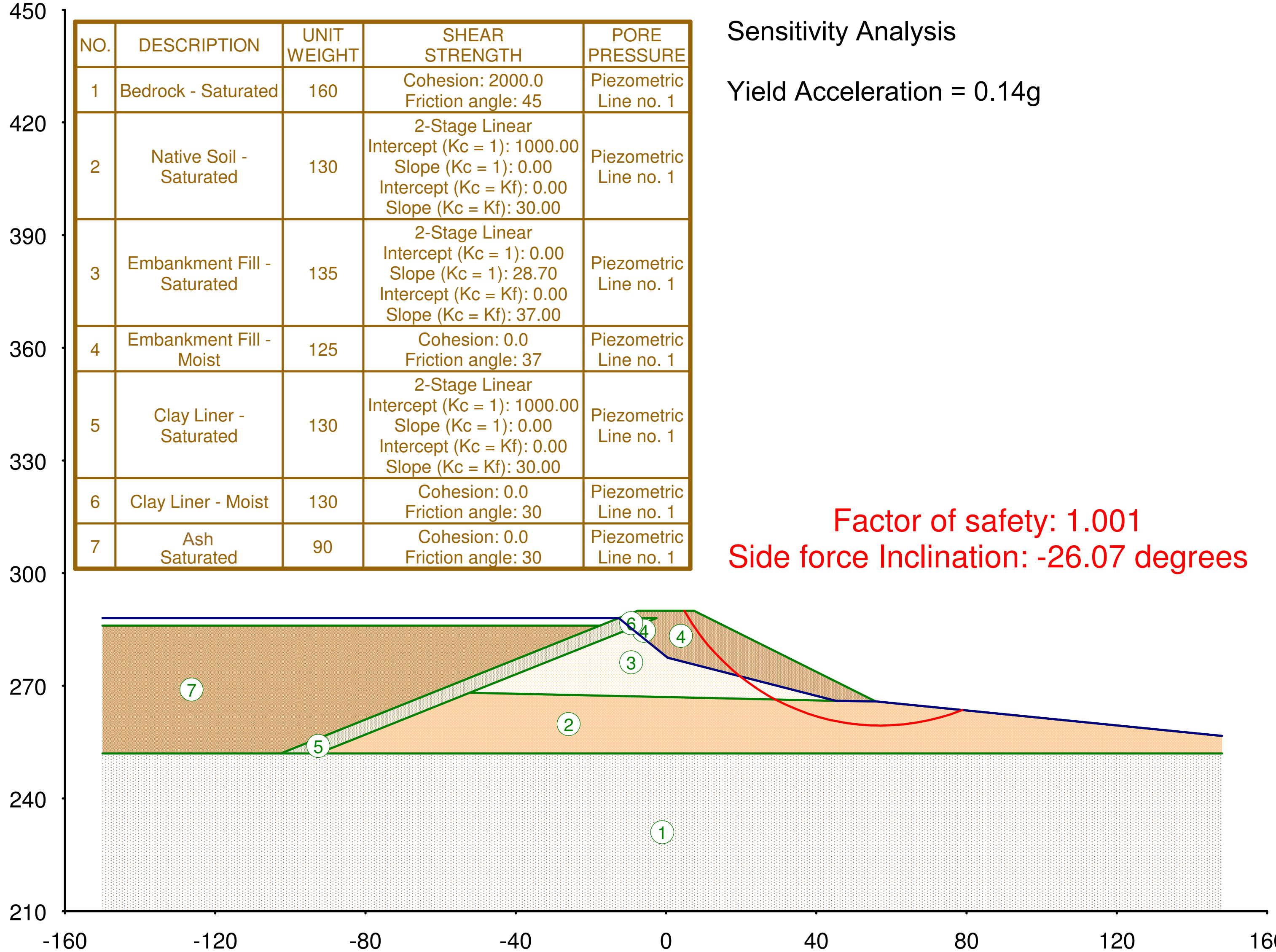
Brunner Island - Ash Basin No.6 - Sta. 21+80 - Yield Acceleration = 0.14 g

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Bedrock - Saturated	160	Cohesion: 2000.0 Friction angle: 45	Piezometric Line no. 1
2	Native Soil - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Embankment Fill - Saturated	135	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 28.70 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 37.00	Piezometric Line no. 1
4	Embankment Fill - Moist	125	Cohesion: 0.0 Friction angle: 37	Piezometric Line no. 1
5	Clay Liner - Saturated	130	2-Stage Linear Intercept (Kc = 1): 1000.00 Slope (Kc = 1): 0.00 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
6	Clay Liner - Moist	130	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
7	Ash Saturated	90	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1

Sensitivity Analysis

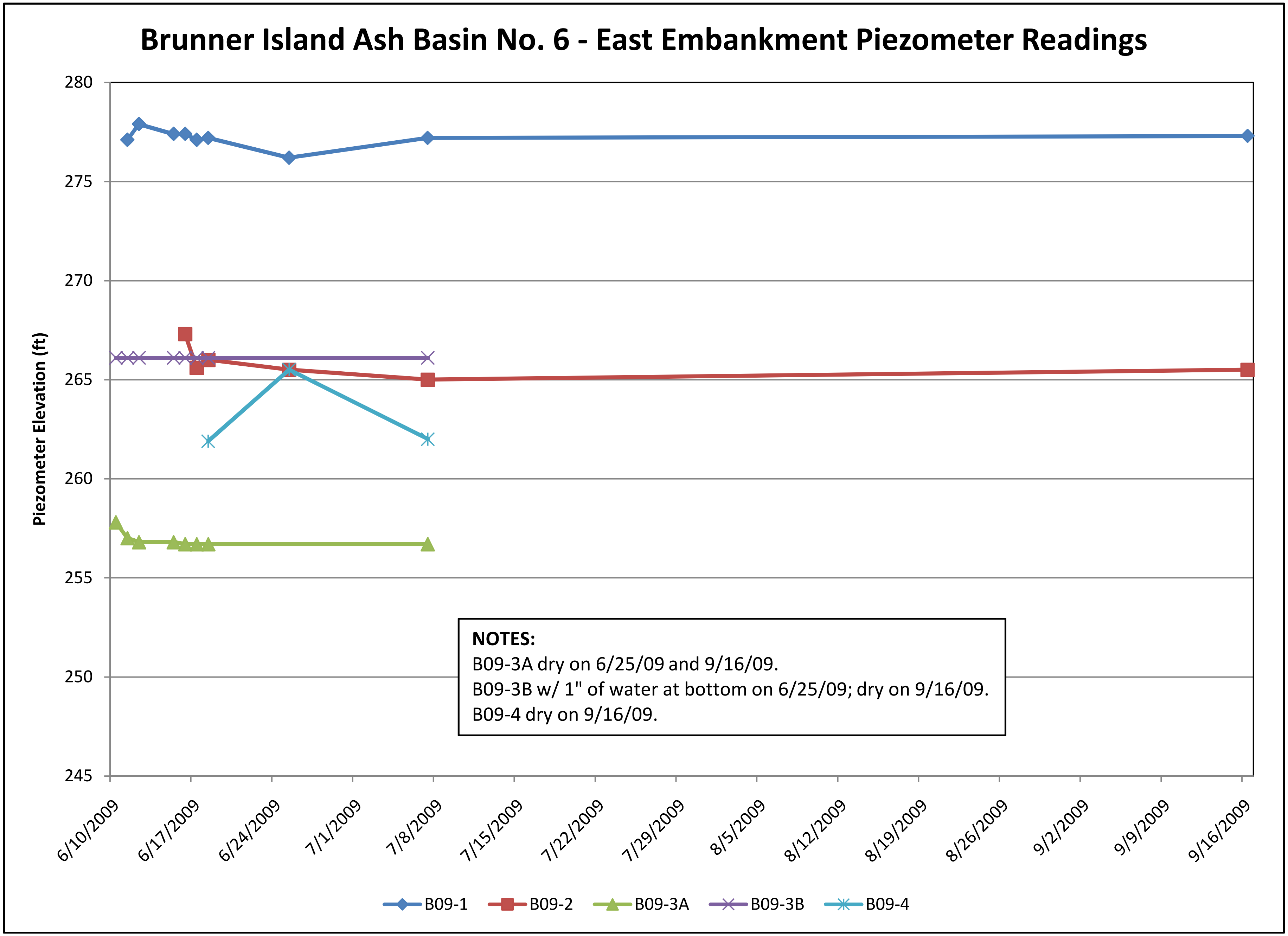
Yield Acceleration = 0.14g

Factor of safety: 1.001
Side force Inclination: -26.07 degrees



Filename: C:\PPL_AshBasin\Brunner_Analysis_2009\Analysis\Brunner Island_Ash Basin No.6_Sta.21+80_Yield ATime: 13:06:36

APPENDIX F
PIEZOMETER PLOTS


Brunner Island Ash Basin No. 6 - East Embankment Piezometer Readings
Piezometer Elevation (ft)
280
275
270
265
260
255
250
245
6/10/2009
6/17/2009
6/24/2009
7/1/2009
7/8/2009
7/15/2009
7/22/2009
7/29/2009
8/5/2009
8/12/2009
8/19/2009
8/26/2009
9/2/2009
9/9/2009
9/16/2009
NOTES:
B09-3A dry on 6/25/09 and 9/16/09.
B09-3B w/ 1" of water at bottom on 6/25/09; dry on 9/16/09.
B09-4 dry on 9/16/09.
B09-1
B09-2
B09-3A
B09-3B
B09-4

APPENDIX G
REFERENCES

France, J. W. and Winckler, Christina J. C. “Rapid Drawdown Analysis: What is an analyst to do?” Association of State Dam Safety Officials Vol. 7, Issue 2 (2009): 28-39.

“Guidelines for Evaluating and Mitigating Seismic Hazards in California.” California Geological Survey Special Publication 117A (2008): 29.

Pennsylvania Department of Environmental Protection (PADEP). Title 25: Environmental Protection, Article II: Water Resources, Chapter 105: Dam Safety and Waterway Management, Subchapter B: Dams and Reservoirs. The Pennsylvania Code.

U.S. Army Corps of Engineers. (USACE) Engineering Manual EM 1110-2-1902: Slope Stability (October 31, 2003).

U.S. Army Corps of Engineers. (USACE) Engineering Manual EM 1110-2-1913: Design and Construction of Levees (April 30, 2000).

GEOTECHNICAL ENGINEERING REPORT

PPL Brunner Island SES Transient Seepage and Slope Stability Study
PPL Contract No. 523528-C
East Manchester Township, York County
Pennsylvania

Schnabel Reference 11615019
February 17, 2012

Schnabel
ENGINEERING

Schnabel
ENGINEERING

February 17, 2012

Mr. James P. Lynch, CCM
PPL Civil TIP Coordinator
GENPL6
2 North 9th Street
Allentown, PA 18101

Subject: **Project 11615019, PPL Brunner Island SES Transient Seepage and Slope Stability Study, Wago Road, East Manchester Township, York County, Pennsylvania**

Dear Mr. Lynch:

SCHNABEL ENGINEERING CONSULTANTS, INC. (Schnabel) is pleased to submit our geotechnical engineering report for this project. This report includes tables, figures, and appendices with relevant data collected for this study. This study was performed in accordance with our proposal dated May 16, 2011, with addendum dated August 29, 2011, as authorized by Mr. Larry Ehrenreich originally on June 2, 2011, and as amended on September 12, 2011.

We appreciate the opportunity to be of service for this project. Please call us if you have any questions regarding this report.

EXECUTIVE SUMMARY

We are providing this executive summary solely for purposes of overview. Any party that relies on this report must read the full report. This executive summary omits several details, any one of which could be very important to the proper application of the report.

This study evaluated the stability of the eastern-most impoundment dike at the Brunner Island Ash Basin No. 6 facility, which is adjacent to the Susquehanna River. A transient seepage analysis was performed to consider slope stability under a rapid drawdown event from a 500-yr recurrence interval (RI) flood corresponding to a river elevation at EL 288.8. The models developed for this evaluation included data from explorations and analyses prepared by others as described herein.

The study suggests a minimum factor of safety (FOS) under rapid drawdown greater than 1.1 for the scenarios and conditions that were considered.

T/ 610-696-6066 F/ 610-696-7771
1380 Wilmington Pike, Suite 100 / West Chester, PA / 19382

SCOPE

Our agreement dated May 16, 2011, as amended by our addendum dated August 29, 2011, defines the scope of this study. Our services included retention of a subconsultant (Advantage Engineers [Advantage]) to perform subsurface exploration, field testing and evaluation, and soil laboratory testing which are included in a Geotechnical Data Summary Report (DSR).

Based on the Geotechnical DSR prepared by Advantage and data provided to us which were developed by others, we completed a transient seepage and slope stability analysis of one of the Brunner Island Ash Basin (AB) No. 6 impoundment dikes. Our analysis focused on the stability of the eastern-most downstream (e.g., river side) slope of the embankment under rapid drawdown of the Susquehanna River from the 500-yr recurrence interval (RI) flood stage elevation. The duration of the various stages described herein is based on our interpretation and evaluation of readily available historical data prepared by others. Our evaluation of the eastern impoundment dike along the Susquehanna River was requested since results of steady state seepage and slope stability analysis performed by another consultant (HDR Engineering, Inc., 2009) indicated that the minimum Factor of Safety (FOS) for slope stability of the downstream slope under a rapid drawdown condition (under steady state seepage) may be unsatisfactory for the eastern impoundment dike.

Pennsylvania Power and Light (PPL) provided a copy of the HDR Engineering Report (2009) to Schnabel, as well as a copy of a report prepared by Borings, Soils & Testing Company (BST, 1977) which was prepared to evaluate foundation conditions for Ash Storage Basins 6 and 7 at the Brunner Island facility. For the project described herein, Schnabel prepared a transient seepage and slope stability analysis for the downstream slope of the eastern Brunner Island impoundment dike at AB No. 6 under a rapid drawdown condition. This report presents our approach and the results of our evaluation.

Services not described in our agreement are not included in this study. We would be happy to provide any additional services to the project team that are required.

PROJECT APPROACH

The HDR Report (2009) included subsurface exploration, piezometer installation, and testing and evaluation at two cross section locations on the eastern impoundment dike (Section 1 at Sta. 21+80 and Section 2 at Sta. 7+44). The geometry and subsurface soil conditions were nearly identical at the two cross section locations; however, water levels observed in the Section 1 piezometers were found to be higher than at Section 2. The higher phreatic surface at Section 1 would make that section more critical for slope stability, so the geometric configuration and piezometric levels based on Section 1 were adopted for this study.

We performed preliminary transient seepage and slope stability analyses based on the parameters adopted in the HDR Report (2009), including embankment geometry, subsurface conditions and stratification, phreatic surface, shear strength (friction angle and cohesion), and unit weights. The HDR Report (2009) did not include testing and evaluation of the embankment soil hydraulic conductivity since analyses were made based upon steady state seepage conditions.

Preliminary transient analyses used a range of reasonable parameters to perform a sensitivity analysis of the transient seepage condition, including the saturated hydraulic conductivity of the embankment soils. The range of values adopted for parameters used in the sensitivity analysis was based upon embankment soil gradation from laboratory testing and visual descriptions in test borings, all performed by others, including values reported in the BST Report (1977).

Our preliminary sensitivity evaluation showed that the penetration of the wetting front during transient seepage caused by rising flood levels in the Susquehanna River, and the subsequent dissipation of pore pressures as the flood levels recede, was mostly dependent on the saturated hydraulic conductivity of the embankment soils. The factor of safety for deep-seated slope failures of the embankment under transient seepage conditions could range from acceptable to unacceptable based on the pore water pressure distribution resulting from various transient models which incorporated reasonable values of hydraulic conductivity. The factors of safety were typically lower as the saturated hydraulic conductivity increased, due to the deeper penetration of the wetting front moving through the embankment during transient seepage. Therefore, it was decided that further characterization of the embankment soils was necessary to complete the dike stability evaluation under rapid drawdown using transient seepage analysis.

SUPPLEMENTAL FIELD EXPLORATION AND LABORATORY TESTING – GEOTECHNICAL DATA SUMMARY REPORT (DSR)

Schnabel retained Advantage Engineers to perform a supplemental field exploration and laboratory testing program, and to summarize the results into a Geotechnical DSR. The subsurface exploration program included the following:

- Five Standard Penetration Test (SPT) Borings located along the crest of the existing embankment extending to a depth of approximately 20 ft (designated TB-C1 through TB-C5).
- Four hand-excavated test pits located mid-way between the riverside embankment toe and crest (designated HA-E1 through HA-E4).

Exploration locations are shown on Figure 1 of the Advantage Report (2012) that is included as Appendix A. Within each of the hand-excavated test pits, in-place soil density and moisture content were measured according to ASTM D1556 (sand cone). The infiltration rate was measured within the test pits using a double ring infiltrometer. Infiltration rates were also measured at depths selected by Schnabel in cased holes advanced as auger probes adjacent to the SPT boring locations. These infiltration tests were performed by Advantage personnel in general accordance with Appendix C of the Pennsylvania Department of Environmental Protection (PADEP) Pennsylvania Stormwater Best Management Practices Manual (PADEP, 2006). Results of the field testing are summarized in Tables I and II of the Advantage Report (2012). In addition to the SPT samples, bulk samples were also collected from auger cuttings over each 5-ft depth interval (e.g., 0-5 ft, 5-10 ft, 10-15 ft, and 15-20 ft) and from the hand-excavated test pits.

Draft test boring logs provided to Schnabel by Advantage were used to select samples to perform initial laboratory testing to further characterize the soils. Samples were selected to evaluate the various types of embankment soils encountered in the field exploration. Embankment soils (based on visual classifications) were generally either: (1) lean clay or silt with varying amounts of sand and gravel; (2)

sand with varying amounts of silt/clay and gravel; or (3) gravel with varying amounts of silt/clay and sand. The initial laboratory testing included the following:

- 50 natural moisture content determinations (ASTM D2216)
- 14 sieve and hydrometer tests (ASTM D422)
- 7 Atterberg (plastic and liquid) Limit determinations (ASTM D4318)

Standard Proctor Tests (ASTM D698) were performed to evaluate the maximum dry unit weight and optimum moisture content of representative samples of the three fundamental embankment soil types. Based on in situ density tests, the average relative compaction (RC) of the embankment soils was approximately 85 percent. While in situ density tests were only performed in the shallow hand-excavated test pits, SPT blowcounts suggest a lower bound average relative compaction of 85 percent for the deeper embankment soils is reasonable as well.

Seven bulk samples were selected for hydraulic conductivity testing (ASTM D5084) to represent the various embankment soil types. Specimens were prepared from the bulk samples, which included samples from the hand auger locations and test borings. Specimens from the hand auger locations were remolded at the approximate in situ moisture content and dry density (as determined from the field testing). Soil samples from test borings were remolded at optimum moisture content and a dry unit weight corresponding to an RC of 85 percent (based on Proctor tests most suitable for each particular soil sample). The complete results of the laboratory testing are included with the Advantage Report (2012) that is provided in Appendix A.

Saturated hydraulic conductivity values for representative embankment soils were evaluated from the seven flexible wall permeameter (ASTM D5084) tests. Saturated hydraulic conductivities were also estimated from the measured infiltration rates using the empirical relationship described by Fritton et al. (1986) which were developed based on tests in Pennsylvania soils. The saturated hydraulic data are summarized in tabular format in Appendix B.

Tables 1 and 2 included in Appendix B summarize the saturated hydraulic conductivity data from the in-situ infiltration testing and laboratory, respectively. Figure 1 in Appendix B is a box plot showing the statistical distribution in the saturated hydraulic conductivity data. Maximum, minimum, average, and lower and upper quartile values of the saturated hydraulic conductivity are shown.

TRANSIENT SEEPAGE ANALYSIS AND MODELING

Seepage was modeled using GeoStudio's SEEP/W (ver 7.14) computer program. SEEP/W is a two-dimensional finite element computer program commonly used to model unconfined and confined seepage problems, including groundwater movement and pore water pressure distribution within porous materials such as soil and rock. SEEP/W can be used to model seepage conditions and evaluate various parameters, including hydraulic head/pore water pressure distribution, hydraulic gradient, volume of flow, and many others. SEEP/W can be used to model both steady state and transient seepage conditions. Steady state conditions include situations in which model parameters (soil properties, boundary conditions, etc.) do not change over time. Transient conditions involve scenarios in which model parameters do change over time.

To model both steady state and transient seepage in SEEP/W, the saturated hydraulic conductivity is required for the underlying soils. Both natural soil deposits and man-made soil structures (e.g., dikes, levees, earthen embankments, etc.) may exhibit anisotropy, which means that the resistance to flow is different in different directions. This means that different values of hydraulic conductivity are required to model flow in different directions (e.g., different values of K_h and K_v for saturated hydraulic conductivity in the horizontal and vertical directions, respectively). Anisotropic hydraulic conductivity can be (and was) modeled in SEEP/W. The saturated hydraulic conductivity values evaluated from the field and laboratory testing are mostly controlled by the vertical hydraulic conductivity of the embankment soils. Finally, boundary conditions associated with the phreatic surface (i.e., the water table) defined in the seepage model must be established.

Transient (non-steady state) seepage modeled in SEEP/W requires definition of additional soil parameters to model unsaturated flow and appropriate boundary conditions applied to the ground surface profile. The boundary conditions can be changed over time to produce realistic stages of varying infiltration and water elevations to various surfaces.

The unsaturated hydraulic conductivity of a soil is both nonlinear and hysteretic. SEEP/W can model the nonlinear relationship between hydraulic conductivity and matric potential/volumetric water content, but cannot model hysteresis. Hysteresis is the phenomena associated with unsaturated flow, whereby the unsaturated hydraulic conductivity is not only a function of the matric potential/volumetric water content, but whether the soil is going through a drying or wetting phase.

Modeling a soils' unsaturated hydraulic conductivity in SEEP/W requires definition of two relationships:

1. The volumetric water content / matric potential curve (VWC-MPC), which defines the non-linear relationship between the volumetric water content and matric potential.

2. The unsaturated hydraulic conductivity / pore water pressure (matric potential) UP-PWP curve, which defines the non-linear relationship between unsaturated hydraulic conductivity and matric potential.

In addition, the coefficient of volume compressibility (m_v) must also be defined.

SEEP/W has several semi-empirical models that can be used to develop the VWC-MPC curves for soils, which depend on the soil type (fine versus coarse grained) and material properties (e.g., plasticity of fine grained soils, grain-size distribution of coarse grained soils, etc.). The pertinent soil properties for the strata (including m_v) were taken from an evaluation of the laboratory test data. The UP-PWP was modeled using the relationship developed by Fredlend and Xing, which depends on the saturated hydraulic conductivity, residual water content, range of matric potential, and VWC-MPC relationship. Details of this model can be found in the SEEP/W User's Manual (GEO-SLOPE International Ltd, 2008) and references included therein. It should be noted that a sensitivity analysis was performed prior to finalizing the transient analysis. The sensitivity analysis revealed that the results from the models were relatively insensitive to residual water content and coefficient of volume compressibility, and showed that the saturated hydraulic conductivity of the dike embankment was the primary factor affecting the stability of the embankment using the pore pressure distribution from a transient seepage analysis under the rapid drawdown condition. This was primarily due to deeper penetration of the wetting front at higher hydraulic conductivities, which did not dissipate over the rapid drawdown time period.

The initial water table must also be defined to perform a transient seepage analysis. The initial water table adopted was identical to that defined in the HDR Report (2009) for the analysis of Section 1 at Sta. 21+80. The water table extended from a normal water level (NWL) at EL 288.0 on the upstream side of the impoundment dike, through the embankment at levels as measured by the two piezometers, daylighting near the downstream toe of the impoundment dike at EL 263.

Once the initial water table and material properties for transient flow were defined for the unsaturated embankment soil in the analysis section, appropriate boundary conditions were assigned. The boundary conditions were established assuming the following staged "rainy day" scenario, which is based on available historical climatic, meteorological, and hydraulic data (including the rise, high stage, and recede time intervals for the storm of record, which is Hurricane Agnes that occurred in June 1972). A summary of the available climatic, meteorological, and hydraulic data that was reviewed for this project is included in Appendix C.

1. DAY 0 to 353: A surface boundary flux was applied representing annual infiltration at a rate twice as great as the average daily precipitation for the project area for a period of 353 days. Based on data from the United States National Oceanic and Atmospheric Administration (NOAA), the average daily precipitation near the project area is about 0.11 inches per day.

2. DAY 353 to 357: The rate of infiltration for the surface boundary flux was increased to correspond to a total of 9 inches of precipitation over a 24 hour period. Based on NOAA data, this corresponds to the 24-hour rainfall from a storm with an RI of 200 years, with a 90% confidence interval (i.e., 95% assurance that the value is less than 9 inches). This flux was applied for a total period of four days, corresponding to a total of 36 inches of rainfall.

3. DAY 357 to 359: The surface boundary flux was reduced back to a value equal to twice the average infiltration rate; however, the river level was raised from a normal water level elevation (considered as the top of bank elevation at EL 252) to the flood elevation corresponding to the 500-year RI flood event (EL 288.8). The river level was increased linearly to the peak elevation over a period of two days.

4. DAY 359 to 363: The river elevation was held at the 500-yr flood elevation for a period of four days.

5. DAY 363 to 365: The river elevation was allowed to recede (fall) to the initial normal water level elevation over a period of two days. This is the time period for rapid drawdown, and the pore water pressure distribution at the end of two days was used for the slope stability analysis under rapid drawdown.

The transient seepage scenario described above was modeled using the following cases based on the saturated hydraulic conductivity used for the impoundment dike embankment:

Isotropic Hydraulic Conductivity
Case 1: $K_v = K_h = 6.8*10^{-6}$ ft/sec (maximum saturated hydraulic conductivity, isotropic)
Case 2: $K_v = K_h = 2.8*10^{-6}$ ft/sec (average saturated hydraulic conductivity, isotropic)
Case 3: $K_v = K_h = 6.8*10^{-9}$ ft/sec (minimum saturated hydraulic conductivity, isotropic)

Anisotropic Hydraulic Conductivity
Case 4: $K_v = 0.50 * K_h = 2.8*10^{-6}$ ft/sec (average saturated hydraulic conductivity, anisotropy ratio = 2)
Case 5: $K_v = 0.25 * K_h = 2.8*10^{-6}$ ft/sec (average saturated hydraulic conductivity, anisotropy ratio = 4)
Case 6: $K_v = 0.13 * K_h = 2.8*10^{-6}$ ft/sec (average saturated hydraulic conductivity, anisotropy ratio = 8)

Representative plates displaying graphical output from the transient seepage analyses are provided in Appendix D for Cases 1 and 3. As suggested earlier, Plates D2a and D3a in Appendix D illustrate how the lower saturated hydraulic conductivity limits the penetration of the wetting front through the embankment.

DEEP-SEATED GLOBAL SLOPE STABILITY ANALYSIS

The downstream side of the impoundment dike was evaluated for global stability using Spencer's Method as implemented in GeoStudio's SLOPE/W (ver 7.14) computer program. Soil parameters (unit weight, shear strength, etc.) used in the HDR Report (2009) were adopted for the slope stability analyses. The transient seepage analysis was used to model the change in pore water pressure over time (as described previously), and effective shear strengths were used in the stability model.

Spencer's Method was used to evaluate global slope stability of the downstream slope using the pore water pressure distribution from SEEP/W. The minimum FOS resulting from the rapid drawdown (flood recede over two days) from a 500-yr flood stage to normal water levels in the river was calculated at discrete time increments starting at flood stage and ending when river levels return to the normal water level elevation. Only deep-seated potential failure planes were considered, which are failure planes that extend from the crest of the embankment beyond the downstream embankment toe.

Plates displaying graphical output from the global slope stability analyses are provided in Appendix E for Case 2 at selected stages during rapid drawdown (Plates E2a through E2d), and at the completion of drawdown for all cases (Cases 1 through 6 in Plates E3a through E3f, respectively). The following table summarizes the minimum FOS for rapid drawdown that was calculated for Cases 1 through 6.

Minimum Factor of Safety for Rapid Drawdown: Cases 1 through 6

CONDITION	Min. FOS (Plate #)
Isotropic Hydraulic Conductivity	
Case 1: $K_v = K_h = 6.8*10^{-6}$ ft/sec (max sat hydr cond, isotropic)	1.13 (E3a)
Case 2: $K_v = K_h = 2.8*10^{-6}$ ft/sec (avg sat hydr cond, isotropic)	1.22 (E3b)
Case 3: $K_v = K_h = 6.8*10^{-9}$ ft/sec (min sat hydr cond, isotropic)	1.32 (E3c)
Anisotropic Hydraulic Conductivity	
Case 4: $K_v = 0.50 * K_h = 2.8*10^{-6}$ ft/sec (avg sat hydr cond, anisotropy ratio = 2)	1.20 (E3d)
Case 5: $K_v = 0.25 * K_h = 2.8*10^{-6}$ ft/sec (avg sat hydr cond, anisotropy ratio = 4)	1.17 (E3e)
Case 6: $K_v = 0.13 * K_h = 2.8*10^{-6}$ ft/sec (avg sat hydr cond, anisotropy ratio = 8)	1.13 (E3f)

CONCLUSIONS

Conventional guidelines for minimum factors of safety include recommendations in United States Army Corps of Engineers (USACE) engineering manuals. Recommended minimum values of 1.1 (drawdown from maximum surcharge pool) to 1.3 (drawdown from maximum storage pool) are provided for new earth and rock-fill dams in Table 3-1 in USACE EM 1110-2-1902 (USACE 2003). Recommended minimum values of 1.0 to 1.2 for new and existing levees, and other embankments and dikes, are provided in USACE EM 1110-2-1913 (USACE 2000).

The minimum FOS for stability of the downstream embankment slope under the rapid drawdown scenarios presented herein corresponds to a value of 1.13, which is greater than the value of 1.1 for earth dams drawn down from maximum surcharge pool (which most closely represents the scenario used in this study). The study used a flood event with a 500-yr RI, so floods with more frequent RI's (e.g., 50-yr, 100-yr, etc.) would result in even higher factors of safety if all other factors remain the same.

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LIMITATIONS

We based the analyses and recommendations submitted in this report on the information revealed by the exploration performed by others, and interpretation of data prepared by others. We attempted to provide for normal contingencies, but the possibility remains that unexpected conditions may exist.

We prepared this report to aid in the evaluation of this site and to assist in the geotechnical evaluation described herein. We intend it for use concerning this specific project. We based our recommendations on information on the site and understanding of information as described in this report.

We have endeavored to complete the services identified herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions as this project. No other representation, express or implied, is included or intended, and no warranty or guarantee is included or intended in this report, or any other instrument of service.

We appreciate the opportunity to be of service for this project. Please call us if you have any questions regarding this report.

Sincerely,

SCHNABEL ENGINEERING CONSULTANTS, INC.

Scott A. Raschke, PhD, PE
Senior Associate

JMB:SAR:PIW:jlc

Appendix A: Advantage Geotechnical Data Summary Report
Appendix B: Summary of Saturated Hydraulic Conductivity Data
Appendix C: Summary of Climatic, Meteorological, and Hydraulic Conductivity Data
Appendix D: Seepage Analysis Plates
Appendix E: Slope Stability Analysis Plates

Distribution:
PPL Generation, LLC (2)
Attn: Mr. James P. Lynch

APPENDIX A

ADVANTAGE GEOTECHNICAL DATA SUMMARY REPORT (2012)

ADVANTAGE ENGINEERS

GEOTECHNICAL DATA SUMMARY REPORT

PPL ASH BASIN
BRUNNER ISLAND TRANSIENT SEEPAGE AND EMBANKMENT STABILITY STUDY

YORK HAVEN, YORK COUNTY, PENNSYLVANIA

PREPARED FOR:

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MANAGING PARTNER

ADVANTAGE PROJECT NO. - 1100517

JANUARY 2012

telecommunications | environmental | geotechnical

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ADVANTAGE ENGINEERS

TABLE OF CONTENTS

1.0 INTRODUCTION

This report was prepared by Advantage Engineers, LLC (Advantage), on behalf of Schnabel Engineering Consultants, Inc. (Schnabel), of West Chester, Pennsylvania, and contains the results of a subsurface geotechnical engineering study and laboratory testing program conducted at the site of the existing ash basin at the PPL Brunner Island power generation facility in York Haven, Pennsylvania. The purpose of this investigation has been to gather supplemental subsurface data to establish the parameters required for Schnabel to complete the final seepage and stability analysis.

The scope of work for this project included the completion of a subsurface field investigation, laboratory testing program, and preparation of this geotechnical data summary report. This report summarizes the results of the work performed and provides factual geotechnical engineering data for use in Schnabel's engineering analysis.

2.0 SITE AND PROJECT DESCRIPTION

The project site currently consists of the eastern earthen embankment of Ash Basin No. 6 at the existing PPL Brunner Island power generation facility in York Haven, York County, Pennsylvania. The site is bordered to the east by the Susquehanna River, to the south by undeveloped property and the Susquehanna River, to the west by the existing Ash Basin No. 6, and to the north by Ash Basin No. 5. The approximate location of the site in relation to the surrounding area is presented on the attached *Topographic Map*.

3.0 SUBSURFACE INVESTIGATION PROGRAM

In an effort to evaluate subsurface conditions within the existing earthen embankment, a series of standard SPT earth borings and hand-dug test pits were conducted in September and October 2011, in accordance with the following schedule:

- Five (5) test borings along the crest of the existing embankment, each extending to a termination depth of approximately 20 feet below existing site grades.
- Four (4) hand-dug test pits within the embankment, each extending to a depth of approximately 2 to 3 feet below existing site grades.

Supervision and monitoring of the field operation were provided by a representative of Advantage. The test borings and test pits were field surveyed and staked by Schnabel in advance of our field investigation. The approximate locations of the test borings and test pits, designated as TB-C1 through TB-C5 and HA-E1 through HA-E4, respectively, are shown on *Figure 1 – Brunner Island SES Impoundment Dike Supplemental Exploration Locations*, prepared by Schnabel, presented in the Appendix.

The test borings were advanced using a truck-mounted CME-55 drilling rig equipped with hollow-stem augers and an automatic hammer. Split-spoon samples, conducted in accordance with ASTM standard D1586, were taken throughout the entire depth of the borings and the Standard Penetration Test (SPT) values were recorded for each sample obtained. The SPT values, which are a measure of relative density or consistency, are the number of blows required to drive a 2-inch (outer-diameter), split-barrel sampler 2 feet using a 140-pound weight dropped 30 inches. The number of blows required to advance the sampler over the 12-inch interval from 6 to 18 inches is considered the "N" value.

Data pertaining to the subsurface investigation was documented in the field and is presented in detail on the *Test Boring Logs*, presented within the Appendix. The *Test Boring Logs* contain general information about the subsurface program and specific data regarding each test boring, including: sample depths, blow counts per six (6) inches of penetration, and detailed characterizations of the subsurface materials encountered.

Within each of the hand-excavated test pits, the in-place density and moisture content were determined via Sand Cone Method (ASTM D1556). In addition, infiltration testing was conducted at varying depths within auger probes adjacent to the test boring locations using the "cased pipe method" and within the test pit locations via a "double ring infiltrometer".

4.0 SUMMARY OF IN-SITU FIELD TESTING

A summary of the results of the field moisture-density testing and infiltration analyses are presented below in Tables I and II. Additional details of the testing completed are presented in the Appendix.

TABLE I

SAND CONE TEST RESULTS – ASTM D1556				
Test Location	HA-E1	HA-E2	HA-E3	HA-E4
Moisture Content (%)	12.4	9.6	8.5	5.4
Wet Density (pcf)	123.2	117.6	126.9	132.5
Dry Density (pcf)	109.5	107.3	117.0	125.7

TABLE II

INFILTATION TEST RESULTS – CASED PIPE & DOUBLE-RING METHODS			
Test Location	**Test Depth (ft)**	**Test Method**	**Infiltration Rate (in/hr)**
TB-C1	8.0	CASED PIPE	1.08
TB-C2	5.0	CASED PIPE	0.60
TB-C3	8.0	CASED PIPE	4.68
TB-C4	4.0	CASED PIPE	0.36
TB-C5	4.5	CASED PIPE	NO MEASURABLE RATE
HA-E1	2.0	DOUBLE-RING	0.20
HA-E2	2.0	DOUBLE-RING	0.84
HA-E3	2.3	DOUBLE-RING	0.31
HA-E4	2.5	DOUBLE-RING	0.25

5.0 LABORATORY TESTING

All soils encountered at the site were visually reviewed and classified by Advantage personnel. The client selected samples collected from the field investigation for laboratory analysis. Advantage delivered the samples to GTS Laboratories where they were subjected to the following analyses:

- 50 natural moisture content determinations per ASTM D2216
- 14 sieve & hydrometer analyses per ASTM D422
- 7 Atterberg Limits (Liquid and Plastic Limits) per ASTM D4318
- 3 Standard Proctor analyses per ASTM D698
- 7 hydraulic conductivity/permeability tests per ASTM D5084 flexible wall permeameter

A detailed account of the laboratory testing completed is presented in the Appendix of this report.

6.0 DESCRIPTION OF CONDITIONS ENOUNTERED

6.1 SOIL

The surfaces of the test borings were found to be covered by approximately 4 to 6 inches of crushed stone (gravel road base). Beneath the topsoil, subsurface conditions were found to be generally homogenous throughout the embankment ranging from silty sand and gravel to sandy clay with gravel. In general, the soils encountered consisted of rounded sand and gravel with varying amounts of silt and clay. Based on the laboratory testing completed, the fines content ranges from approximately 11.5% to 66.8% and the soils are of low to moderate plasticity.

6.2 GROUNDWATER

Groundwater was encountered and measured only within test boring TB-C4 at a depth of approximately 11.3 feet below existing site grades at completion of the test boring. Water was not encountered within the remaining test borings or hand-excavated test pits completed at the project site. These observations were made at the time of the field investigation and groundwater elevations will change with daily, seasonal, and climatological variations.

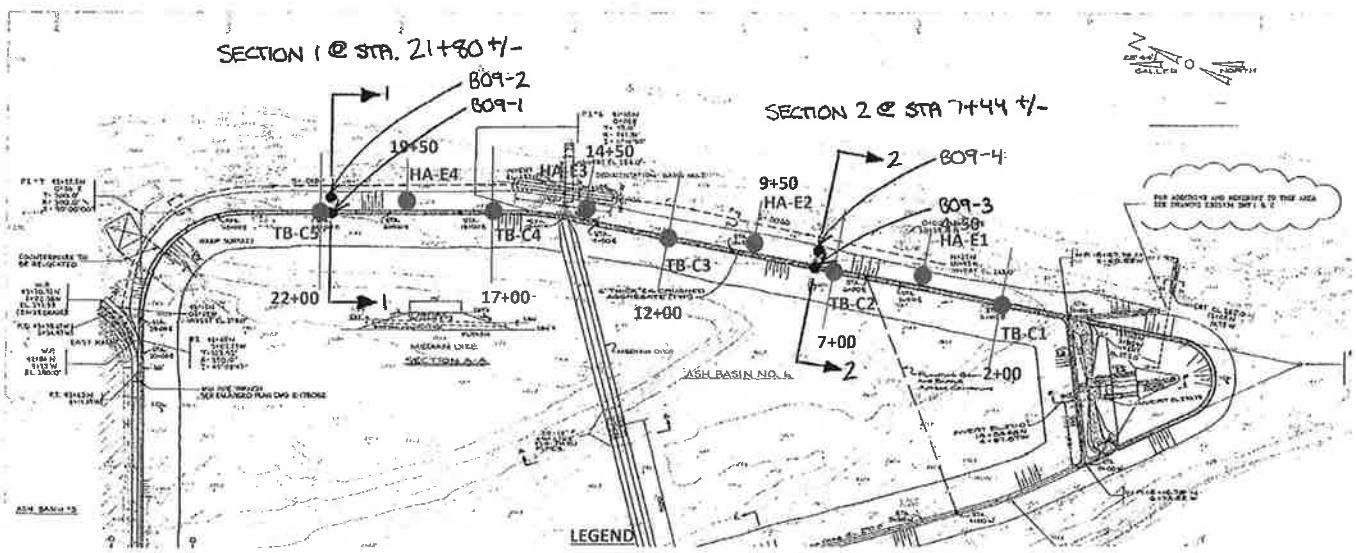
7.0 LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical design practices for specific application to this project. This report has been based on assumed conditions and characteristics of the proposed development where specific information was not available.

It is emphasized that this geotechnical investigation was completed for the areas indicated on the plan enclosed with this report and described herein. The validity of the projections and data contained in this report may be affected by the number of borings completed. The recommendations presented herein are based upon the number of borings purchased by the owner and while, depending upon the actual nature of subsurface conditions, those projections and conclusions may accurately set forth the nature of the subsurface conditions where the borings were made, the data presented herein are not to be applied to the remainder of the site.

APPENDIX

Figure 1 - Brunner Island SES Impoundment Dike Supplemental Exploration Locations



Screen clipping taken: 8/18/2011, 10:42 AM

- TB-C1 - Approximate SPT Test Boring Location
- HA-E1 - Approximate Hand Auger Location

TEST BORING LOG

SHEET 1 OF 1

PROJECT NAME: PPL Ash Basin 6 - Brunner Island Seepage & Embankment Stability Study
PROJECT NUMBER: 1100517
CLIENT: Schnabel Engineering Consultants, Inc.
LOCATION: Station 2+00

BORING NO.: TB-C1

FIELD SURVEYED ☐ TOPO ESTIMATE ☐

ELEV

TOP OF GROUND:
GROUNDWATER DATA: Dry
Depth: Not Encountered
Time: Completion

DEPTH (feet)	SAMPLE NUMBER	SAMPLE DEPTH (ft)	BLOWS PER 6"		SOIL DESCRIPTION	REMARKS
				0.0'-0.5'	Gray sand and gravel	**Road Base**
	S1	0'-2'	23-17-19-21	0.5' - 7.25'	Very stiff brown sandy clay with gravel; 100% Recovery	Uc= >4.5TSF
	S-2	2'-4'	8-7-13-14		Very stiff brown sandy clay; some gravel; [moist]	Uc= 1.5TSF
5						
	S3	4'-6'	8-6-4-9		Stiff brown sandy clay with gravel; [no gravel; moist to wet from 5'-5.5'] 100% Recovery	Uc= 2.5TSF Uc= 1.25TSF
	S4	6'-8'	10-15-18-20	7.25' - 8.0'	Very dense brown clayey sand with gravel	100% Recovery
				8.0' - 12.0'		
10	S5	8'-9.3'	16-49-50/4"		Very dense brown sand and rounded gravel; some silt	100% Recovery
	S6	10'-12'	23-30-35-38		Very dense brown sand and rounded gravel; some silt	100% Recovery
				12.0' - 14.0'	Very dense brown silty fine to medium sand with gravel; [moist from 13.0' - 14.0']	
	S7	12'-14'	32-34-29-35			100% Recovery
15				14.0' - 15.5'	Very dense brown sand and rounded gravel; some silt	
	S8	14'-16'	20-21-16-12	15.5' - 16.25'	Very stiff brown fine sandy clay; trace gravel	100% Recovery
				16.25' - 17.5'	Very dense brown sand and rounded gravel; some silt	
	S9	16'-18'	15-21-20-21	17.5' - 18.0'	Very dense brown silty fine sand	100% Recovery
				18.0' - 20.0'		
20	S10	18'-20'	17-22-31-44		Very dense sand and rounded gravel; some silt	100% Recovery
					-End of Boring at 20.0 feet-	
25						

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RIG TYPE: Truck-Mounted CME-55
DRILLING METHOD: Hollow Stem Auger
ADVANTAGE REP.: Brian K. Hilsabeck
DRAWN/COMPILED BY: Brian K. Hilsabeck
DATE DRILLED: September 12, 2011

TEST BORING LOG

SHEET 1 OF 1

PROJECT NAME: PPL Ash Basin 6 - Brunner Island Seepage & Embankment Stability Study

PROJECT NUMBER: 1100517

BORING NO.: TB-C2

CLIENT: Schnabel Engineering Consultants, Inc.

ELEV

TOP OF GROUND:

GROUNDWATER DATA: Dry

Depth: Not Encountered

Time: Completion

LOCATION: Station 7+00

FIELD SURVEYED

TOPO ESTIMATE

DEPTH (feet)	SAMPLE NUMBER	SAMPLE DEPTH (ft)	BLOWS PER 6"		SOIL DESCRIPTION	REMARKS
				0.0'-0.3'	Gray sand and gravel	**Road Base**
	S1	0'-2'	20-12-12-18	0.3' - 2.0'	Very stiff brown clay; some sand, some gravel; 100% rec.	Uc= >4.5TSF
				2.0' - 3.0'	Very dense brown clayey sand with rounded gravel	
	S-2	2'-4'	11-17-14-15	3.0' - 4.0'	Very stiff brown clay; some sand, some gravel; 100% rec.	Uc= >4.5TSF
5				4.0' - 4.75'	Very dense brown clayey sand with rounded gravel	
	S3	4'-6'	6-10-17-20	4.75' - 5.25'	Very stiff brown clay	100% Recovery
				5.25' - 6.0'	Very dense brown clayey sand with rounded gravel	Cave at 6.5'
	S4	6'-8'	18-15-13-21	6.0' - 8.0'	Very stiff brown sandy clay with gravel; 30% Recovery	
				8.0' - 16.0'		
10	S5	8'-10'	15-25-22-23		Very dense brown sand and rounded gravel; some silt	100% Recovery
	S6	10'-12'	20-32-24-13		Very dense brown sand and rounded gravel; some silt	100% Recovery
	S7	12'-14'	11-23-30-31		Very dense brown sand and rounded gravel; some silt	100% Recovery
15						
	S8	14'-16'	19-30-21-26		Very dense brown clayey sand with rounded gravel; -tan to yellow sand seam from 15.0' - 15.25'	100% Recovery
				16.0' - 17.0'	Very dense brown clayey sand with rounded gravel	
	S9	16'-18'	23-18-18-22	17.0' - 17.5'	Very stiff brown clay; Uc= 3.5TSF	100% Recovery
				17.5' - 18.0'	Very dense brown silty fine sand	
20	S10	18'-20'	6-11-10-15	18.0' - 20.0'	Very stiff brown to gray clay; some fine sand; Uc= >4.5TSF	100% Recovery
					-End of Boring at 20.0 feet-	
25						

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www.advantageengineers.com

RIG TYPE: Truck-Mounted CME-55

DRILLING METHOD: Hollow Stem Auger

ADVANTAGE REP.: Brian K. Hilsabeck

DRAWN/COMPILED BY: Brian K. Hilsabeck

DATE DRILLED: September 12, 2011

TEST BORING LOG

SHEET 1 OF 1

PROJECT NAME: PPL Ash Basin 6 - Brunner Island Seepage & Embankment Stability Study
PROJECT NUMBER: 1100517
CLIENT: Schnabel Engineering Consultants, Inc.
LOCATION: Station 12+00

BORING NO.: TB-C3

ELEV

TOP OF GROUND:
GROUNDWATER DATA: Dry
Depth: Not Encountered
Time: Completion

☐ FIELD SURVEYED ☐ TOPO ESTIMATE

DEPTH (feet)	SAMPLE NUMBER	SAMPLE DEPTH (ft)	BLOWS PER 6"		SOIL DESCRIPTION	REMARKS
				0.0'-0.4'	Gray sand and gravel	**Road Base**
	S1	0'-2'	35-20-18-12	0.4' - 2.0'	Very stiff brown sandy clay with rounded gravel; 100% rec.	Uc= >4.5TSF
	S-2	2'-4'	8-8-13-21	2.0' - 5.5'	Very dense brown clayey sand with rounded gravel	70% Recovery
5						
	S3	4'-6'	13-17-12-18	5.5' - 6.0'	Very stiff brown sandy clay with rounded gravel; 100% rec.	Uc= 3.5TSF
	S4	6'-8'	13-17-15-13	6.0' - 8.0'	Very dense brown clayey sand with rounded gravel	100% Recovery
10	S5	8'-10'	14-21-23-12	8.0' - 10.0'	Very dense brown silty sand and rounded gravel; 4" clay seam from 9.0' - 9.3'; Uc=>4.5TSF	100% Recovery
				10.0' - 10.75'	Very stiff brown sandy clay; trace gravel	Uc= >4.5TSF
	S6	10'-12'	19-24-22-42	10.75' - 12.0'	Very dense brown sand with rounded gravel; some silt	100% Recovery
	S7	12'-14'	31-25-20-48	12.0' - 16.0'	Very dense brown clayey sand with rounded gravel	100% Recovery
15						
	S8	14'-16'	10-10-20-25		Very dense brown clayey sand with rounded gravel; [MOIST]	100% Recovery
	S9	16'-18'	38-31-27-31	16.0' - 18.0'	Very dense brown silty sand and rounded gravel; Light brown silty fine sand from 17.75' to 18.0'	100% Recovery
				18.0' - 19.0'	Very dense brown clayey sand with rounded gravel	
20	S10	18'-20'	19-25-26-23	19.0' - 19.2'	Very dense light brown silty fine sand	100% Recovery
				19.2' - 20.0'	Very stiff brown clay; trace sand, trace gravel Uc=>4.5TSF	
					-End of Boring at 20.0 feet-	
25						

ADVANTAGE ENGINEERS

910 Century Drive, Mechanicsburg, PA 17055
(717) 458-0800 FAX: (717) 458-0801
www.advantageengineers.com

RIG TYPE: Truck-Mounted CME-55

DRILLING METHOD: Hollow Stem Auger

ADVANTAGE REP.: Brian K. Hilsabeck

DRAWN/COMPILED BY: Brian K. Hilsabeck

DATE DRILLED: September 2, 2011

TEST BORING LOG

SHEET 1 OF 1

PROJECT NAME: PPL Ash Basin 6 - Brunner Island Seepage & Embankment Stability Study
PROJECT NUMBER: 1100517
BORING NO.: TB-C4
CLIENT: Schnabel Engineering Consultants, Inc.

ELEV

TOP OF GROUND:
GROUNDWATER DATA: Wet
Depth: 11.3 ft
Time: Completion

LOCATION: Station 17+00

☐ FIELD SURVEYED ☐ TOPO ESTIMATE

DEPTH (feet)	SAMPLE NUMBER	SAMPLE DEPTH (ft)	BLOWS PER 6"		SOIL DESCRIPTION	REMARKS
				0.0'-0.3'	Gray sand and gravel	**Road Base**
	S1	0'-2'	35-20-18-12	0.3' - 2.0'	Very dense brown clayey sand with rounded gravel	70% Recovery
				2.0' - 3.0'	Very stiff brown clay; some sand, some rounded gravel	Uc= >4.5TSF
	S-2	2'-4'	8-8-13-21	3.0' - 4.0'	Very dense brown sand and rounded gravel; some clay	100% Recovery
5				4.0' - 5.25'	Very dense brown clayey sand with rounded gravel	
	S3	4'-6'	13-17-12-18	5.25' - 6.0'	Very stiff brown clay; some sand, some rounded gravel	Uc= >4.5TSF
				6.0' - 8.0'		
	S4	6'-8'	13-17-15-13		Very dense brown clayey sand with rounded gravel	60% Recovery
				8.0' - 9.5'	Very dense brown silty sand and rounded gravel	
10	S5	8'-10'	14-21-23-12	9.5' - 10.0'	Very dense brown clayey sand with rounded gravel	83% Recovery
				10.0' - 12.0'	Very stiff brown clay; some sand; gravel and sand from 10.2' to 10.4' and 11.8' to 12.0'; 100% Recovery	Uc= >4.5TSF
	S6	10'-12'	19-24-22-42			**H_2O at 11.3'**
				12.0' - 17.25'		
	S7	12'-14'	31-25-20-48		Very dense brown clayey sand with rounded gravel; [WET from 12.1' to 12.2' and 13.25' to 13.5']	100% Recovery
15						
	S8	14'-16'	10-10-20-25		Very dense brown clayey sand with rounded gravel; [WET]	45% Recovery
	S9	16'-18'	38-31-27-31	17.25' - 18.0'	Very stiff brown clay; some sand, some gravel [DRY]	Uc= 4.0TSF
				18.0' - 18.25'	Very dense brown clayey sand with rounded gravel [WET]	
20	S10	18'-20'	19-25-26-23	18.25' - 20.0'	Very dense light brown silty fine sand [DRY]	100% Recovery
					-End of Boring at 20.0 feet-	
25						

ADVANTAGE ENGINEERS

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www.advantageengineers.com

RIG TYPE: Truck-Mounted CME-55

DRILLING METHOD: Hollow Stem Auger

ADVANTAGE REP.: Brian K. Hilsabeck

DRAWN/COMPILED BY: Brian K. Hilsabeck

DATE DRILLED: September 2, 2011

TEST BORING LOG

SHEET 1 OF 1

PROJECT NAME: PPL Ash Basin 6 - Brunner Island Seepage & Embankment Stability Study
PROJECT NUMBER: 1100517
CLIENT: Schnabel Engineering Consultants, Inc.

BORING NO.: TB-C5

LOCATION: Station 22+00

FIELD SURVEYED | TOPO ESTIMATE

ELEV

TOP OF GROUND:
GROUNDWATER DATA: Dry
Depth: Not Encountered
Time: Completion

DEPTH (feet)	SAMPLE NUMBER	SAMPLE DEPTH (ft)	BLOWS PER 6"		SOIL DESCRIPTION	REMARKS
				0.0'-0.4'	Gray sand and gravel	**Road Base**
	S1	0'-2'	18-12-21-29	0.4' - 2.0'	Very dense brown silty sand with rounded gravel	100% Recovery
				2.0' - 6.5'		
	S-2	2'-4'	8-13-10-10		Very stiff brown sandy clay; some rounded gravel; 75% Recovery, Uc= >4.5TSF	
5						
	S3	4'-6'	12-10-10-13		Very stiff brown sandy clay with rounded gravel; 100% Recovery, Uc= >4.5TSF	
				6.5' - 10.0'		Cave at 7.0 ft
	S4	6'-7.4'	10-32-50/5"		Very dense brown silty sand with rounded gravel; 42% Recovery; auger chatter from 7.0' to 7.7'	
10	S5	8'-10'	8-16-17-16		Very dense brown clayey sand with rounded gravel; 83% Recovery; Uc= 2.0TSF	
				10.0' - 11.0'	Very stiff brown sandy clay with rounded gravel	Uc= >4.5TSF
	S6	10'-12'	6-15-16-23	11.0' - 12.0'	Very dense brown sand with rounded gravel; some silt	100% Recovery
				12.0' - 13.25'	Very stiff brown sandy clay, some rounded gravel	Uc= >4.5TSF
	S7	12'-14'	9-16-19-50	13.25' - 14.0'	Very dense brown silty sandy rounded gravel	
15				14.0' - 15.5'	Very dense brown silty sand with rounded gravel	100% Recovery
	S8	14'-16'	16-25-29-24	15.5' - 16.0'		Uc= >4.5TSF
				16.0'-16.5'	Very dense brown silty sand with rounded gravel	
	S9	16'-18'	18-24-26-22	16.5 - 17.5'	Very stiff brown sandy clay with rounded gravel	Uc= >4.5TSF
				17.5' - 18.0	Very dense brown clayey sand with rounded gravel	100% Recovery
				18.0' - 18.5'	Very dense brown silty fine sand	
20	S10	18'-20'	10-7-9-13	18.5' - 19.75'	Very stiff brown sandy clay; trace gravel;	Uc= >4.5TSF
				19.75' - 20.0'	Brown silty sand with gravel from 100% Recovery	
					-End of Boring at 20.0 feet-	
25						

ADVANTAGE ENGINEERS

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www.advantageengineers.com

RIG TYPE: Truck-Mounted CME-55

DRILLING METHOD: Hollow Stem Auger

ADVANTAGE REP.: Brian K. Hilsabeck

DRAWN/COMPILED BY: Brian K. Hilsabeck

DATE DRILLED: September 1, 2011

ADVANTAGE ENGINEERS

Density and Unit Weight of Soil in Place by Sand-Cone Method

(per ASTM Designation D 1556)

Date:	September 2, 2011	**Project:**	PPL Ash Basin - Brunner Island Transient Seepage & Embankment Stability Study
Client:	Schnabel Engineering Consultants, Inc.	**Project No.:**	1100517

Test Number	1	2	3	4	5
Material					
Test Location	HA-E1	HA-E2	HA-E3	HA-E4	
Test Elevation/Lift					
Wt. of sand before (lbs.)	14.43	15.22	15.55	15.58	
Wt. of sand after (lbs.)	4.32	5.71	6.98	3.06	
Wt. of sand in cone (lbs.)	3.82	3.82	3.82	3.82	
Wt. of sand in hole (lbs.)	6.29	5.69	4.75	8.70	
Volume of hole (ft³)	0.0645	0.0583	0.0487	0.0892	
Wt. of wet soil (lbs.)	7.94	6.86	6.18	11.82	
Moisture sample wet wt. (g)	3601.5	3111.6	2801.9	5361.5	
Moisture sample dry wt. (g)	3202.8	2838.1	2581.7	5085.7	
Wt. of water in sample	398.7	273.5	220.2	275.8	
Percent field moisture (%)	**12.4%**	**9.6%**	**8.5%**	**5.4%**	
Wt. of dry soil (lbs.)	7.06	6.26	5.69	11.21	
Wet density (lbs./ft³)	123.2	117.6	126.9	132.5	
Dry density (lbs./ft³)	109.5	107.3	117.0	125.7	
Field compaction (%)					
Maximin unit weight (lbs./ft³)					
Optimum moisture content (%)					
Specified compaction					

The results stated on this report relate only to the material specifically identified.
These relative humidity results reflect the condition of the concrete floor at the time of this test.
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Reviewed by: ____________________

6520 Stonegate Drive, Suite 110, Allentown, Pennsylvania 18106
(610) 366-7120 (610) 366-7121 (fax)

RESULTS OF INFILTRATION ANALYSIS			
TEST PIT LOCATION	INVERT ELEVATION (feet below existing grade)	TEST METHOD	INFILTRATION RATE (in/hr)
TB-C1	8.0	CASE-PIPE	1.08
TB-C2	5.0	CASE-PIPE	0.6
TB-C3	8.0	CASE-PIPE	4.68
TB-C4	4.0	CASE-PIPE	0.36
TB-C5	4.5	CASE-PIPE	No Measurable Rate
HA-E1	2.0	DOUBLE RING	0.2
HA-E2	2.0	DOUBLE RING	0.84
HA-E3	2.25	DOUBLE RING	0.31
HA-E4	2.5	DOUBLE RING	0.25

910 Century Drive, Mechanicsburg, Pennsylvania 17055
(717) 458-0800 (717) 458-0801(fax)

Schnabel ENGINEERING

Schnabel Engineering Consultants, Inc.
PPL Ash Basin Brunner Island
Transient Seepage and Slope Stability Study
Addendum No. 1 - Additional Project Data Acquisition
Laboratory Testing Assignments

Date: 9/19/2011
By: SAR

Test: NMC (D2216)

No.	9	2	4	2	10	1	4	2	10	2
Depth (ft)										
0	TB-C1		TB-C2		TB-C3		TB-C4		TB-C5	
1	S-1		S-1		S-1		S-1		S-1	
2										
3	S-2	B-1	S-2	B-1	S-2	B-1	S-2	B-1	S-2	B-1
4										
5	S-3		S-3		S-3		S-3		S-3	
6										
7	S-4		S-4		S-4		S-4		S-4	
8		B-2		B-2		B-2		B-2		B-2
9	S-5		S-5		S-5		S-5		S-5	
10										
11	S-6		S-6		S-6		S-6		S-6	
12										
13	S-7	B-3	S-7	B-3	S-7	B-3	S-7	B-3	S-7	B-3
14										
15	S-8		S-8		S-8		S-8		S-8	
16										
17	S-9		S-9		S-9		S-9		S-9	
18		B-4		B-4		B-4		B-4		B-4
19	S-10		S-10		S-10		S-10		S-10	
20										

					TOT
No.	1	1	1	1	50
Depth (ft)					
0	HA-E1	HA-E2	HA-E3	HA-E4	
1					
2	B-1	B-1	B-1	B-1	
3					
4					
5					

S-1, etc (split spoon samples)
B-1, etc (bulk samples from auger cuttings)

GTS TECHNOLOGIES

MOISTURE CONTENT OF SOIL
AASHTO T-265 or ASTM D-2216

Project #: 11001-37
Project: Ash Basin #6, Brunner Island
Date: 9/21/2011

BORING NO.	SAMPLE NO.	weight of tare	weight wet soil + tare	weight dry soil + tare	MOISTURE CONTENT (%)
TB-C1	S-1	9.08	237.11	213.58	11.51
TB-C1	S-2	8.50	253.36	220.59	15.45
TB-C1	S-3	9.31	282.13	247.16	14.70
TB-C1	S-4	9.15	251.67	234.34	7.70
TB-C1	S-5	8.74	290.61	276.88	5.12
TB-C1	S-6	8.42	312.79	298.70	4.85
TB-C1	S-7	9.28	354.27	331.85	6.95
TB-C1	S-8	6.87	288.79	254.89	13.67
TB-C1	S-9	9.10	169.75	154.48	10.50
TB-C1	S-10	9.10	261.55	251.41	4.18
TB-C2	S-3	8.44	266.79	250.60	6.69
TB-C2	S-4	8.60	245.19	230.57	6.59
TB-C2	S-6	8.39	343.67	326.88	5.27
TB-C2	S-10	8.47	209.17	184.78	13.83
TB-C3	S-1	8.39	276.92	253.45	9.58
TB-C3	S-2	9.04	232.54	220.62	5.63
TB-C3	S-3	9.12	238.25	207.22	15.66
TB-C3	S-4	8.47	282.53	266.98	6.02
TB-C3	S-5	8.40	309.30	293.70	5.47
TB-C3	S-6	8.31	290.48	276.73	5.12
TB-C3	S-7	8.56	221.14	209.12	5.99
TB-C3	S-8	8.49	275.95	259.08	6.73
TB-C3	S-9	9.08	208.12	192.72	8.39
TB-C3	S-10	9.22	257.26	228.48	13.13
TB-C4	S-3	8.44	271.87	247.22	10.32
TB-C4	S-4	8.35	90.44	84.24	8.17
TB-C4	S-6	8.28	238.10	210.35	13.73
TB-C4	S-8	9.02	353.44	328.99	7.64
TB-C4	S-9	8.45	199.45	185.05	8.15
TB-C5	S-1	9.11	244.77	224.65	9.33
TB-C5	S-2	8.65	221.71	195.09	14.28
TB-C5	S-3	9.79	284.40	251.00	13.85
TB-C5	S-4	9.70	233.75	214.37	9.47
TB-C5	S-5	9.60	238.35	223.62	6.88
TB-C5	S-6	9.86	315.69	297.32	6.39
TB-C5	S-7	9.72	268.09	255.50	5.12
TB-C5	S-8	9.63	221.38	205.62	8.04
TB-C5	S-9	9.72	247.96	236.13	5.23
TB-C5	S-10	9.75	258.41	223.83	16.15

By: DFS Ck'd: MCM

GTS TECHNOLOGIES

AASHTO R18

MOISTURE CONTENT OF SOIL
AASHTO T-265 or ASTM D-2216

Project #: 11001-37
Project: Ash Basin #6, Brunner Island
Date: 9/26/2011

BORING NO.	SAMPLE NO.	weight of tare	weight wet soil + tare	weight dry soil + tare	MOISTURE CONTENT (%)
TB-C1	B-1	42.62	2674.21	2422.81	10.56
TB-C1	B-2	14.38	1314.13	1226.32	7.25
TB-C2	B-2	14.29	1367.91	1289.54	6.15
TB-C2	B-3	43.09	3035.81	2865.74	6.03
TB-C3	B-2	42.59	2772.42	2596.25	6.90
TB-C4	B-2	14.29	1393.91	1308.74	6.58
TB-C5	B-1	11.07	1223.61	1141.27	7.29
TB-C5	B-2	11.68	1311.00	1236.11	6.12
HA-E1	B-1	43.68	3091.70	2877.73	7.55
HA-E2	B-1	43.26	3097.79	2892.80	7.19
HA-E3	B-1	43.87	3099.52	2835.42	9.46
HA-E4	B-1	44.29	3096.24	2888.89	7.29

By: DFS Ck'd: MCM

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Schnabel ENGINEERING

Schnabel Engineering Consultants, Inc.
PPL Ash Basin Brunner Island
Transient Seepage and Slope Stability Study
Addendum No. 1 - Additional Project Data Acquisition
Laboratory Testing Assignments

Date: 9/19/2011
By: SAR

Test: Sieve/Hydr (D422)

Depth (ft)	TB-C1		TB-C2		TB-C3		TB-C4		TB-C5	
No.	2	1	2	1	1	1	1		1	
0										
1	S-1		S-1		S-1		S-1		S-1	
2										
3	S-2	B-1	S-2	B-1	S-2	B-1	S-2	B-1	S-2	B-1
4										
5	S-3		S-3		S-3		S-3		S-3	
6										
7	S-4		S-4		S-4		S-4		S-4	
8		B-2		B-2		B-2		B-2		B-2
9	S-5		S-5		S-5		S-5		S-5	
10										
11	S-6		S-6		S-6		S-6		S-6	
12										
13	S-7	B-3	S-7	B-3	S-7	B-3	S-7	B-3	S-7	B-3
14										
15	S-8		S-8		S-8		S-8		S-8	
16										
17	S-9		S-9		S-9		S-9		S-9	
18		B-4		B-4		B-4		B-4		B-4
19	S-10		S-10		S-10		S-10		S-10	
20										

Depth (ft)	HA-E1	HA-E2	HA-E3	HA-E4	TOT
No.	1	1	1	1	14
0					
1					
2	B-1	B-1	B-1	B-1	
3					
4					
5					

S-1, etc (split spoon samples)
B-1, etc (bulk samples from auger cuttings)

Schnabel ENGINEERING

Schnabel Engineering Consultants, Inc.
PPL Ash Basin Brunner Island
Transient Seepage and Slope Stability Study
Addendum No. 1 - Additional Project Data Acquisition
Laboratory Testing Assignments

Date: 9/19/2011
By: SAR

Test: A. Limits (D4318)

Depth (ft)	TB-C1		TB-C2		TB-C3		TB-C4		TB-C5	
No.	1		1				2		1	
0	TB-C1		TB-C2		TB-C3		TB-C4		TB-C5	
1	S-1		S-1		S-1		S-1		S-1	
2										
3	S-2	B-1	S-2	B-1	S-2	B-1	S-2	B-1	S-2	B-1
4										
5	S-3		S-3		S-3		S-3		S-3	
6										
7	S-4		S-4		S-4		S-4		S-4	
8		B-2		B-2		B-2		B-2		B-2
9	S-5		S-5		S-5		S-5		S-5	
10										
11	S-6		S-6		S-6		S-6		S-6	
12										
13	S-7	B-3	S-7	B-3	S-7	B-3	S-7	B-3	S-7	B-3
14										
15	S-8		S-8		S-8		S-8		S-8	
16										
17	S-9		S-9		S-9		S-9		S-9	
18		B-4		B-4		B-4		B-4		B-4
19	S-10		S-10		S-10		S-10		S-10	
20										

Depth (ft)	HA-E1	HA-E2	HA-E3	HA-E4	TOT
No.	1	1			7
0	HA-E1	HA-E2	HA-E3	HA-E4	
1					
2	B-1	B-1	B-1	B-1	
3					
4					
5					

S-1, etc (split spoon samples)
B-1, etc (bulk samples from auger cuttings)

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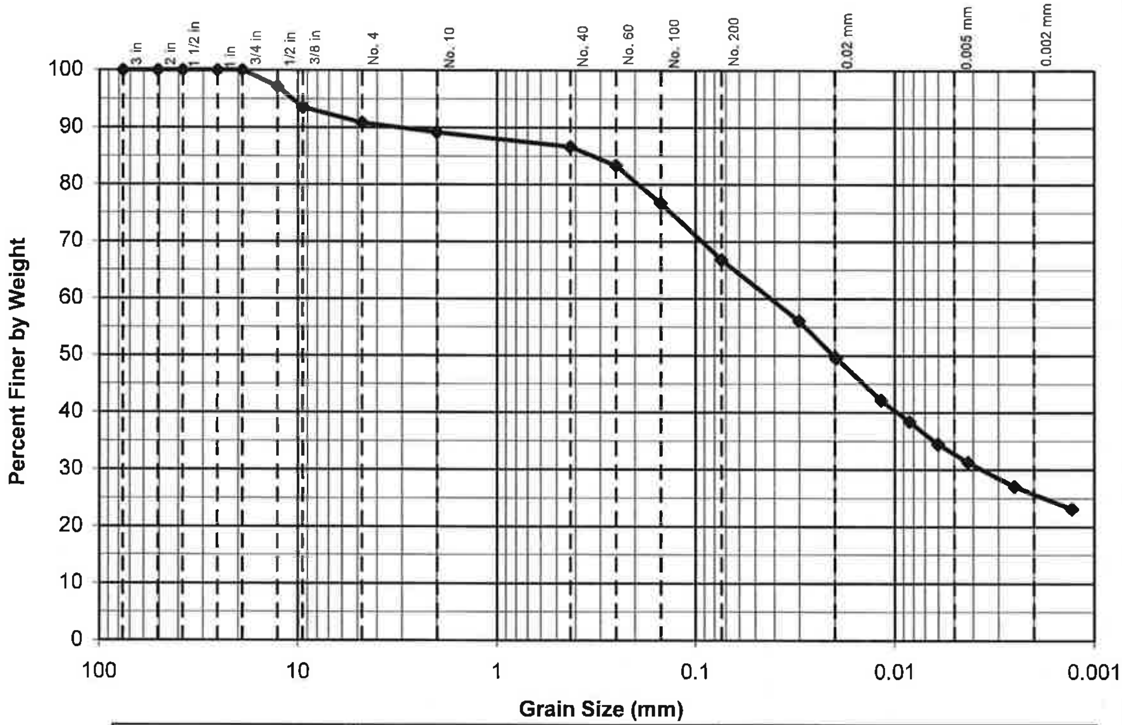
1380 Wilmington Pike, Suite 100 / West Chester, PA / 19382

Grain Size Distribution Curve



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
9.2 %		24.0 %			66.8 %	
0.0 %	9.2 %	1.7 %	2.5 %	19.8 %	34.2 %	32.6 %

USCS

Project:	Ash Basin #6 - Brunner Island	**Soil Type:**	sandy lean CLAY
Boring No.:	TB-C5		
Station:		**Classification:**	CL, A-4 (4)
Offset:		LL = 27 %	PL = 18 %
Sample No.:	S-2	PI = 9 %	w = 14.3 %
Depth:	2.0 - 4.0 ft	**Spec. Grav.:**	2.65 (assumed)

ote: Minimum mass requirement was not met. Mass used for the test = 186.44 grams

GTS TECHNOLOGIES

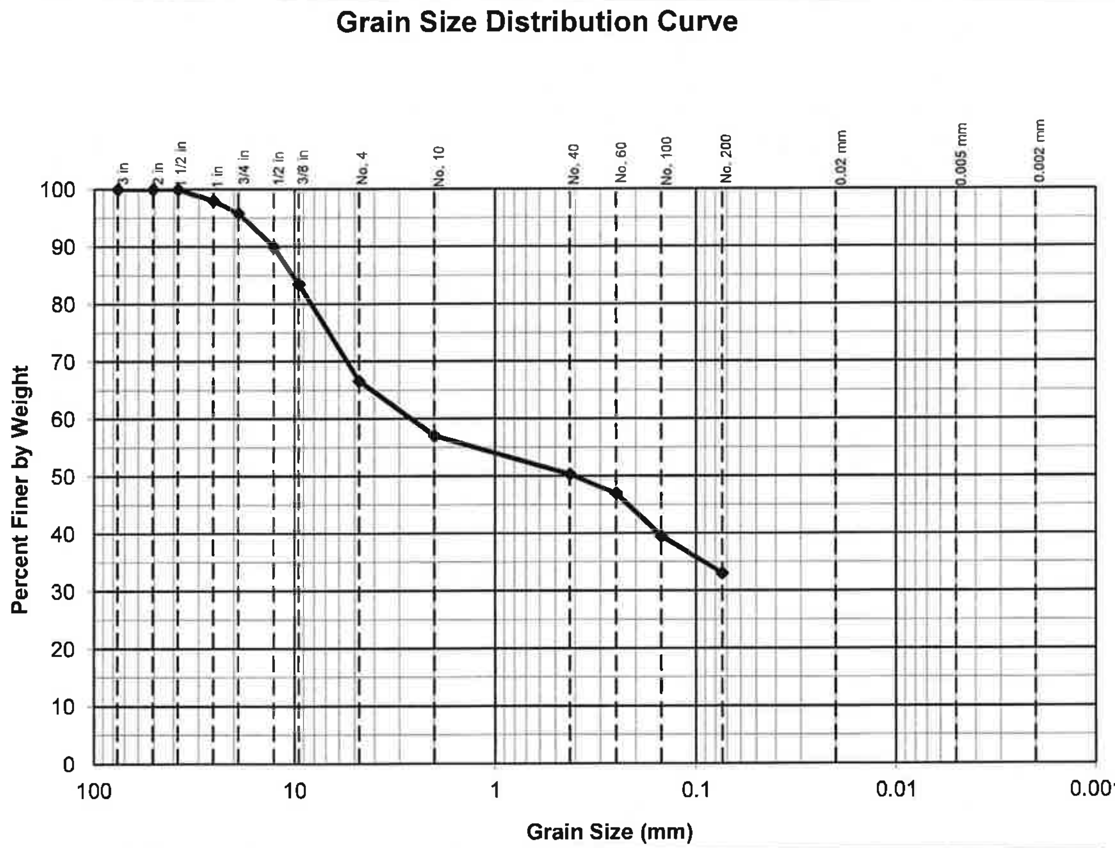
CLASSIFICATION TEST RESULTS

AASHTO T-88, T-89, T-90, M-145
or ASTM D 422, D 4318, D 2487
10/6/2011

GTS No. 11001-37

By: DFS Ckd: MCM

441 Friendship Road . Harrisburg, PA 17111 . Ph: 717/236-3006 . Fax: 717/233-0994 . www.gtstech.com



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
33.4 %		33.5 %				
4.2 %	29.2 %	9.6 %	6.7 %	17.3 %	--	--

USCS

Project: Brunner Island - Ash Basin #6
Boring No.: TB-C5

Sample No.: B-1
Depth: 0.0 - 5.0 ft

GTS TECHNOLOGIES

GRADATION TEST RESULTS

AASHTO T-88
or ASTM 422
10/24/2011

AASHTO R18

GTS No. 11001-37 By: DFS Ckd: dsc

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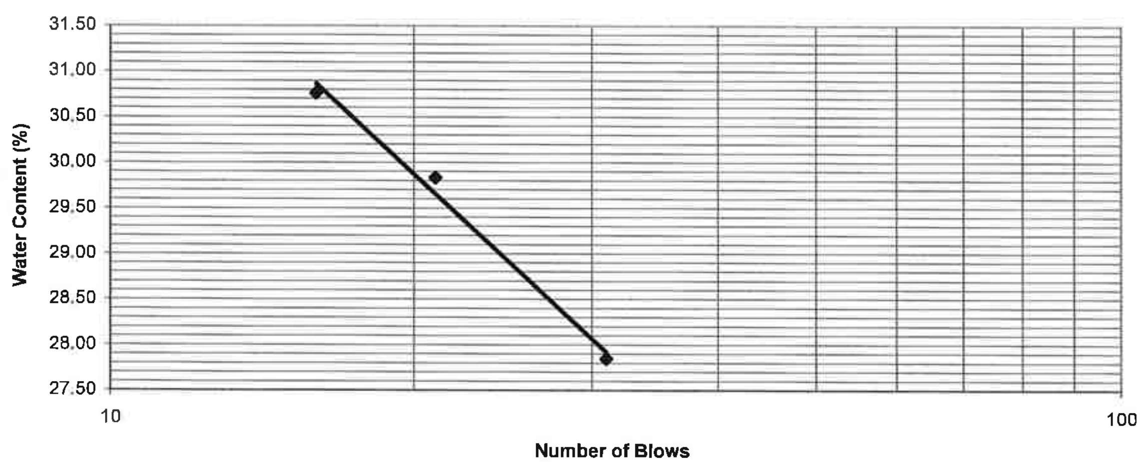
LIQUID LIMIT					
Dish No.					
Blows	31	21	16	0	0
Wt. of Dish	2.48	2.50	2.49	0.00	0.00
Wt. Dish + Wet Soil	14.05	14.25	14.18	0.00	0.00
Wt. Dish + Dry Soil	11.53	11.55	11.43	0.00	0.00
Wt. Of Dry Soil	9.05	9.05	8.94	0.00	0.00
Wt. Of Water	2.52	2.70	2.75	0.00	0.00
% Moist	27.85	29.83	30.76		

PLASTIC LIMIT					
Dish No.					
Wt. of Dish	2.53	2.45	0.00	0.00	0.00
Wt. Dish + Wet Soil	8.95	8.19	0.00	0.00	0.00
Wt. Dish + Dry Soil	7.89	7.24	0.00	0.00	0.00
Wt. Of Dry Soil	5.36	4.79	0.00	0.00	0.00
Wt. Of Water	1.06	0.95	0.00	0.00	0.00
% Moist	19.78	19.83			



Project: Ash Basin #6 - Brunner Island
Boring No.: TB-C4

LL	29 %
PL	20 %
PI	9 %
w	13.7%

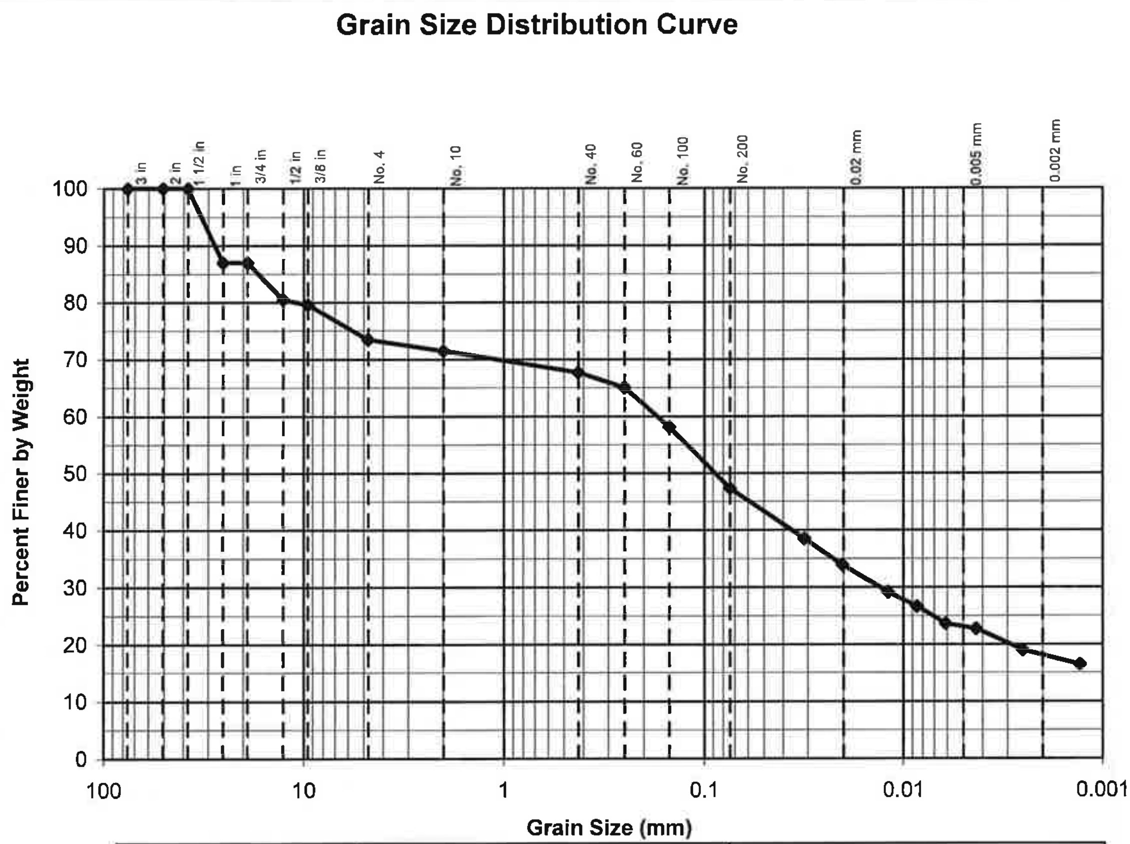
Sample No.: S-6
Depth: 10.0 - 12.0 ft

ATTERBERG LIMITS TEST DATA
AASHTO T-88, T-99 or ASTM 4318

GTS TECHNOLOGIES, INC.
10/7/2011

GTS No. 11001-37

By: DFS Ckd: MCM



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
26.5 %		26.2 %			47.3 %	
13.0 %	13.5 %	2.0 %	3.8 %	20.4 %	24.2 %	23.1 %

USCS

Project:	Ash Basin #6 - Brunner Island	**Soil Type:**	silty, clayey GRAVEL with sand
Boring No.:	TB-C4		
Station:		**Classification:**	GC-GM, A-4 (1)
Offset:		LL = 24 %	PL = 17 %
Sample No.:	S-3	PI = 7 %	w = 10.3 %
Depth:	4.0 - 6.0 ft	**Spec. Grav.:**	2.65 (assumed)

ote: Minimum mass requirement was not met. Mass used for the test = 238.78 grams

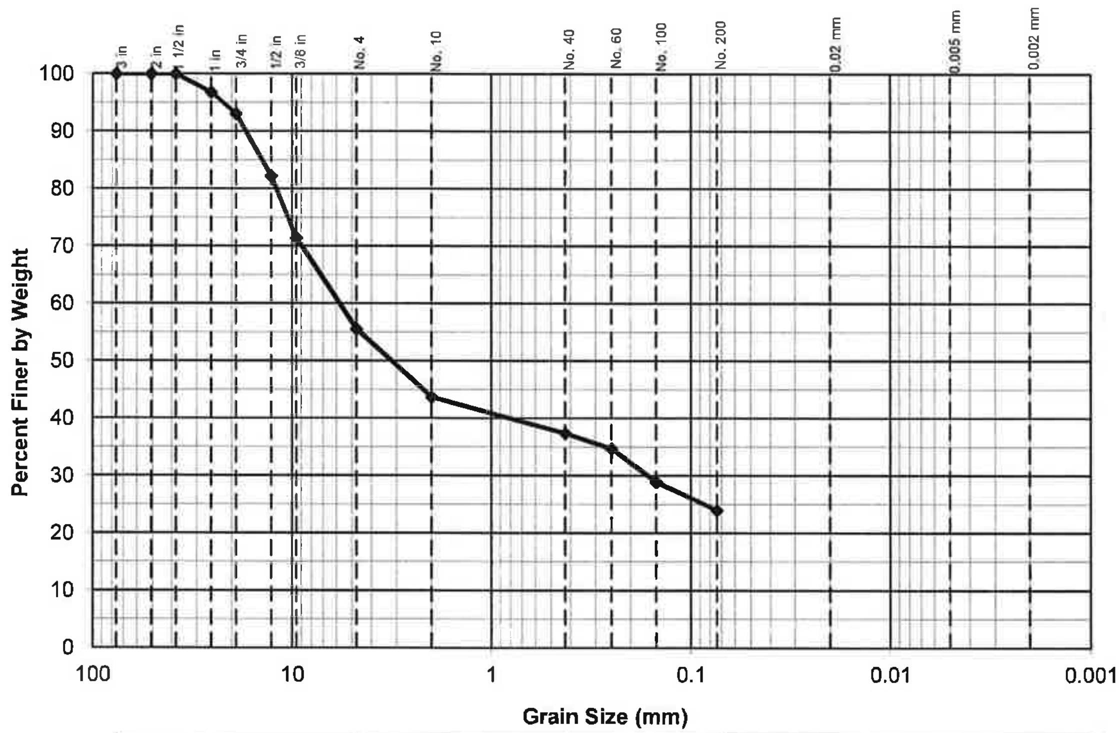
GTS TECHNOLOGIES

CLASSIFICATION TEST RESULTS

AASHTO T-88, T-89, T-90, M-145
or ASTM D 422, D 4318, D 2487
10/5/2011

GTS No. 11001-37 By: DFS Ckd: MCM

Grain Size Distribution Curve



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
44.5 %		31.6 %				
7.0 %	37.5 %	11.9 %	6.3 %	13.4 %	--	--

USCS

Project: Brunner Island - Ash Basin #6
Boring No.: TB-C4

Sample No.: B-2
Depth: 5.0 - 10.0 ft

GTS TECHNOLOGIES

GRADATION TEST RESULTS
AASHTO T-88
or ASTM 422
10/24/2011

AASHTO R18

GTS No. 11001-37

By: KJE Ckd: dsc

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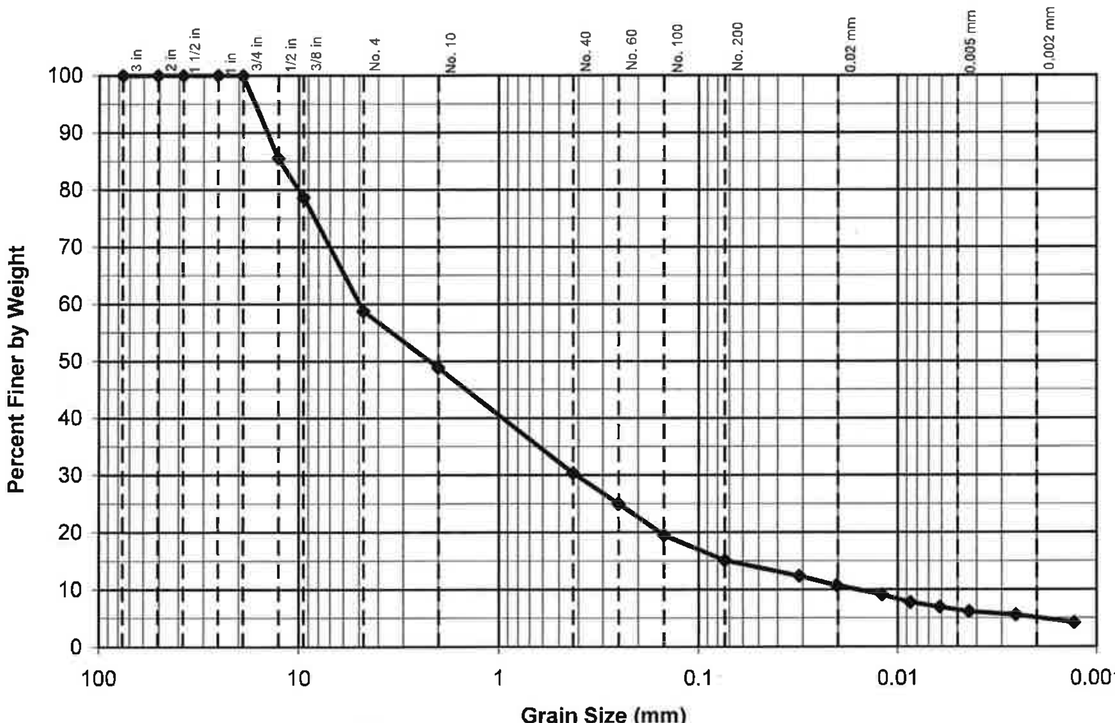
Grain Size Distribution Curve



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
41.3 %		43.6 %			15.1 %	
0.0 %	41.3 %	9.9 %	18.4 %	15.3 %	8.6 %	6.5 %

USCS

Project: Ash Basin #6 - Brunner Island
Boring No.: TB-C3

Sample No.: S-4
Depth: 6.0 - 8.0 ft

Moisture Content: w = 6.0 %

GTS TECHNOLOGIES

GRADATION TEST RESULTS
AASHTO T-88
or ASTM 422
10/6/2011

GTS No. 11001-37

By: DFS Ckd: MCM

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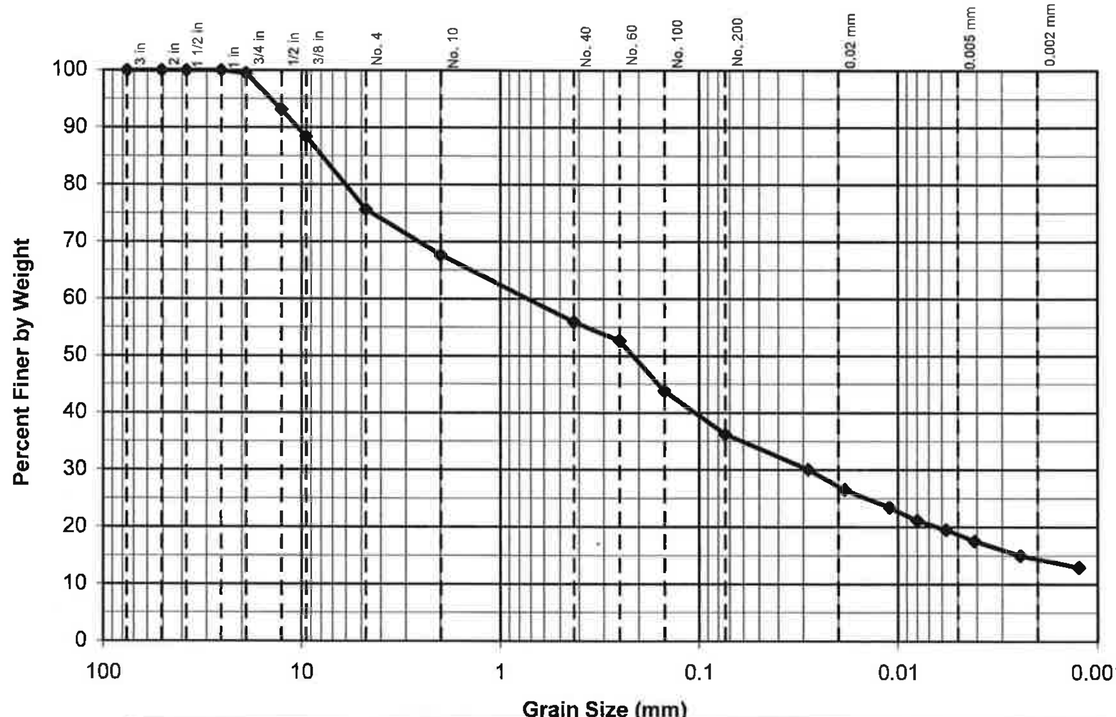
Grain Size Distribution Curve



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
24.4 %		39.4 %			36.2 %	
0.5 %	23.9 %	8.0 %	11.7 %	19.7 %	17.6 %	18.6 %

USCS

Project: Ash Basin #6 - Brunner Island
Boring No.: TB-C3

Sample No.: B-2
Depth: 5.0 - 10.0 ft

Moisture Content: w = 6.9 %

GTS TECHNOLOGIES

GRADATION TEST RESULTS
AASHTO T-88
or ASTM 422
10/6/2011

GTS No. 11001-37

By: DFS Ckd: MCM

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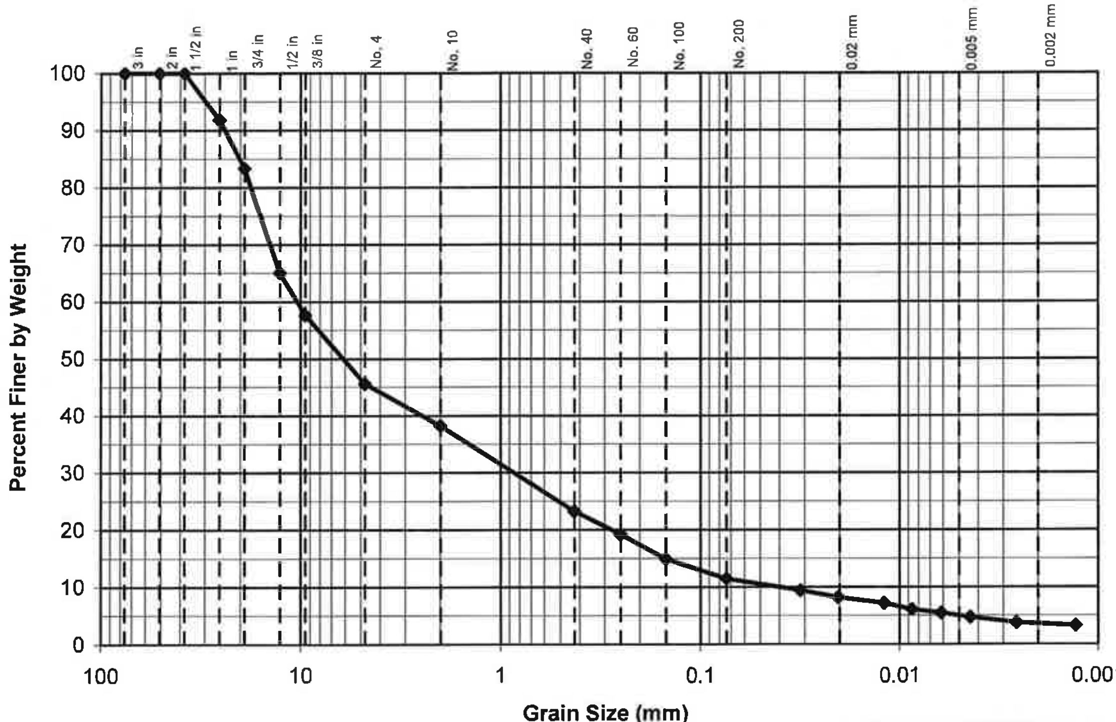
Grain Size Distribution Curve



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
54.4 %		34.1 %			11.5 %	
16.7 %	37.7 %	7.3 %	15.0 %	11.8 %	6.5 %	5.0 %

USCS

Project: Ash Basin #6 - Brunner Island
Boring No.: TB-C2

Sample No.: S-6
Depth: 10.0 - 12.0 ft
Moistur Content: w = 5.3 %

GTS TECHNOLOGIES

GRADATION TEST RESULTS
AASHTO T-88
or ASTM 422
10/6/2011

GTS No. 11001-37 By: DFS Ckd: MCM

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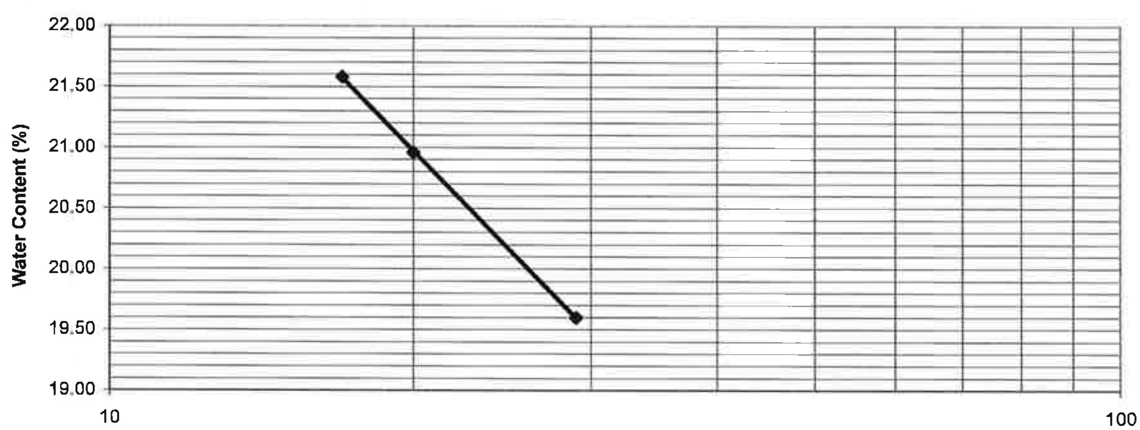
LIQUID LIMIT					
Dish No.					
Blows	29	20	17	0	0
Wt. of Dish	2.55	2.50	2.53	0.00	0.00
Wt. Dish + Wet Soil	12.68	13.58	16.22	0.00	0.00
Wt. Dish + Dry Soil	11.02	11.66	13.79	0.00	0.00
Wt. Of Dry Soil	8.47	9.16	11.26	0.00	0.00
Wt. Of Water	1.66	1.92	2.43	0.00	0.00
% Moist	19.60	20.96	21.58		

PLASTIC LIMIT					
Dish No.					
Wt. of Dish	2.51	2.51	0.00	0.00	0.00
Wt. Dish + Wet Soil	8.21	6.92	0.00	0.00	0.00
Wt. Dish + Dry Soil	7.41	6.29	0.00	0.00	0.00
Wt. Of Dry Soil	4.90	3.78	0.00	0.00	0.00
Wt. Of Water	0.80	0.63	0.00	0.00	0.00
% Moist	16.33	16.67			



Project: Ash Basin #6 - Brunner Island
Boring No.: TB-C2

LL	20 %
PL	16 %
PI	4 %
w	6.6%

Sample No.: S-4
Depth: 6.0 - 8.0. ft

ATTERBERG LIMITS TEST DATA

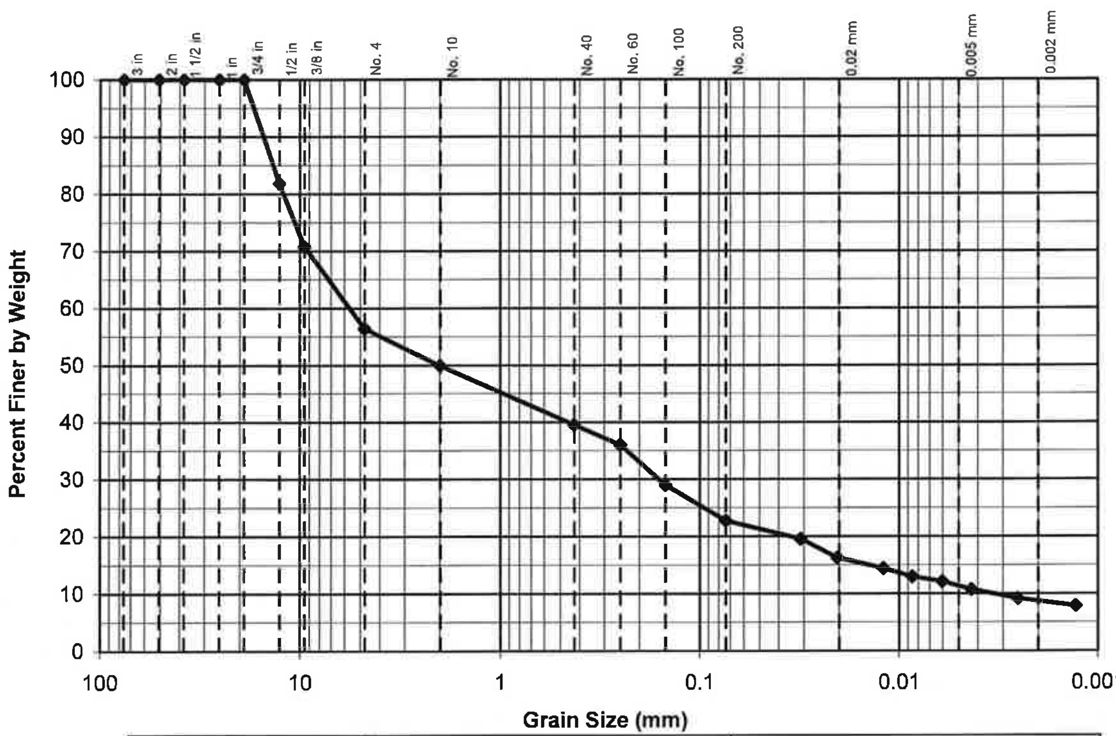
AASHTO T-88, T-99 or ASTM 4318

GTS TECHNOLOGIES, INC.

10/7/2011

By: DFS Ckd: MCM

Grain Size Distribution Curve



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
43.6 %		33.6 %			22.8 %	
0.0 %	43.6 %	6.5 %	10.3 %	16.8 %	11.5 %	11.3 %

USCS

Project: Ash Basin #6 - Brunner Island
Boring No.: TB-C2

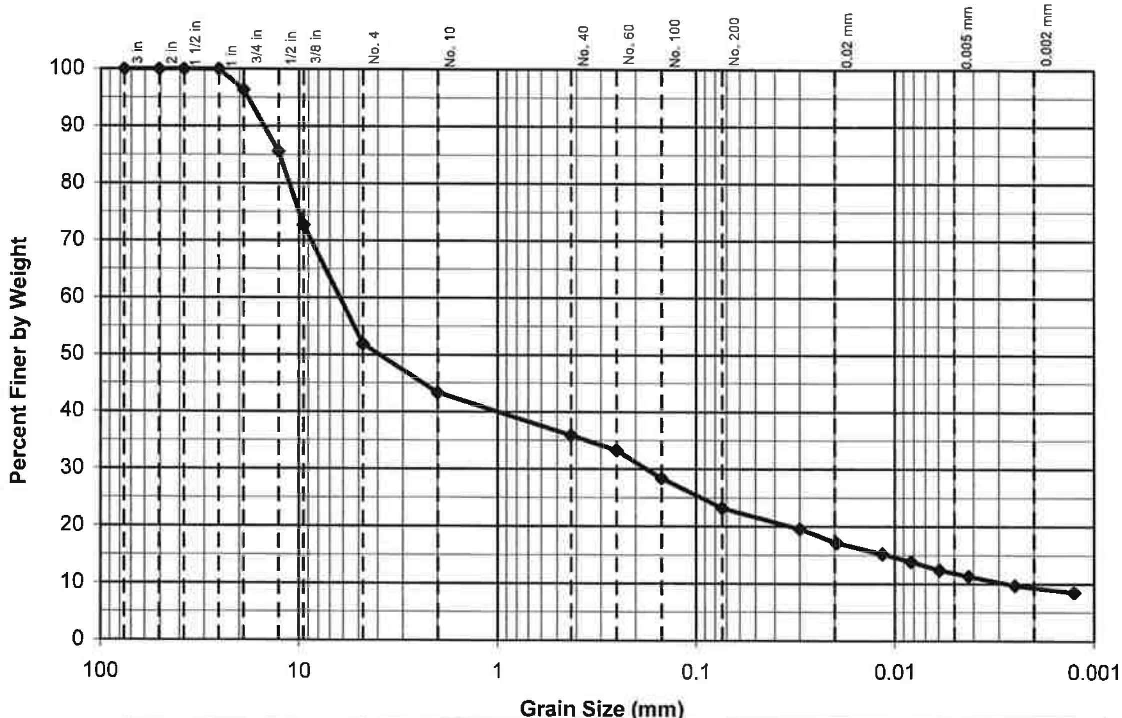
Sample No.: S-3
Depth: 4.0 - 6.0 ft
Moisture Content: w = 6.7 %

GTS TECHNOLOGIES

GRADATION TEST RESULTS
AASHTO T-88
or ASTM 422
10/5/2011

GTS No. 11001-37 By: DFS Ckd: MCM

Grain Size Distribution Curve



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
48.2 %		28.6 %			23.2 %	
3.6 %	44.5 %	8.5 %	7.4 %	12.7 %	11.4 %	11.8 %

USCS

Project: Ash Basin #6 - Brunner Island
Boring No.: TB-C2

Sample No.: B-3
Depth: 10.0 - 15.0 ft

Moisture Content: w = 6.0 %

GTS TECHNOLOGIES

GRADATION TEST RESULTS
AASHTO T-88
or ASTM 422
10/6/2011

GTS No. 11001-37

By: DFS Ckd: MCM

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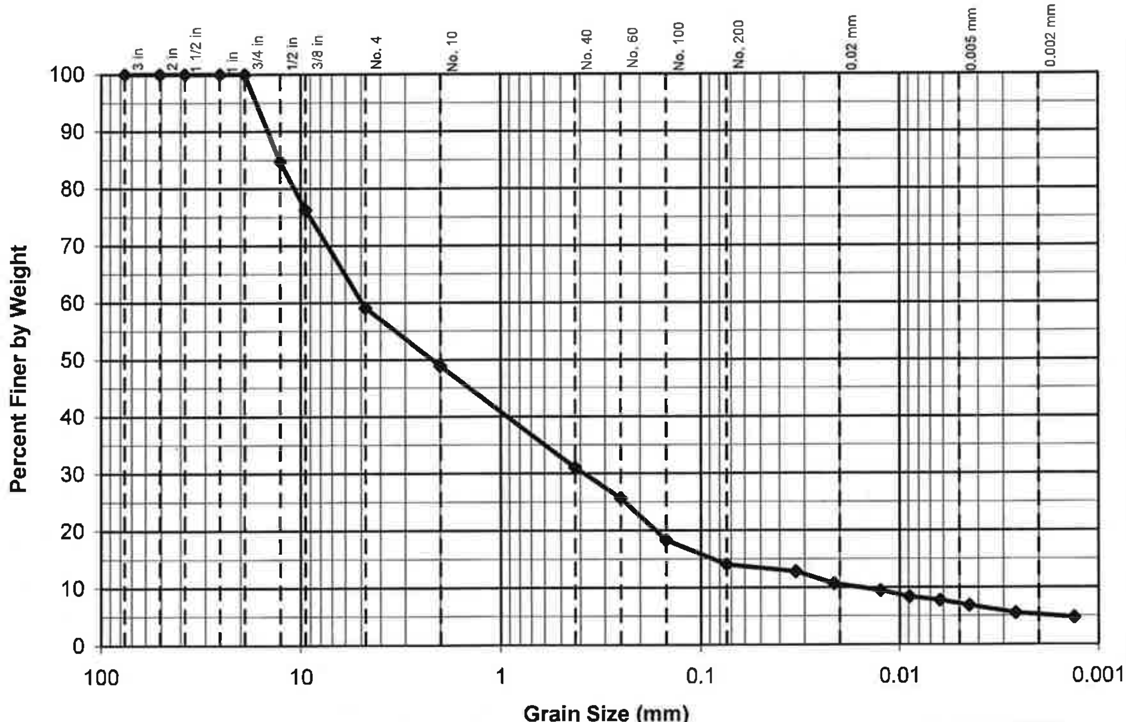
Grain Size Distribution Curve



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
40.9 %		45.0 %			14.0 %	
0.0 %	40.9 %	10.2 %	17.8 %	17.0 %	6.9 %	7.1 %

USCS

Project: Ash Basin #6 - Brunner Island
Boring No.: TB-C1

Sample No.: S-5
Depth: 8.0 - 10. ft

Moisture Content: w = 5.1 %

GTS TECHNOLOGIES

GRADATION TEST RESULTS
AASHTO T-88
or ASTM 422
10/5/2011

GTS No. 11001-37

By: DFS Ckd: MCM

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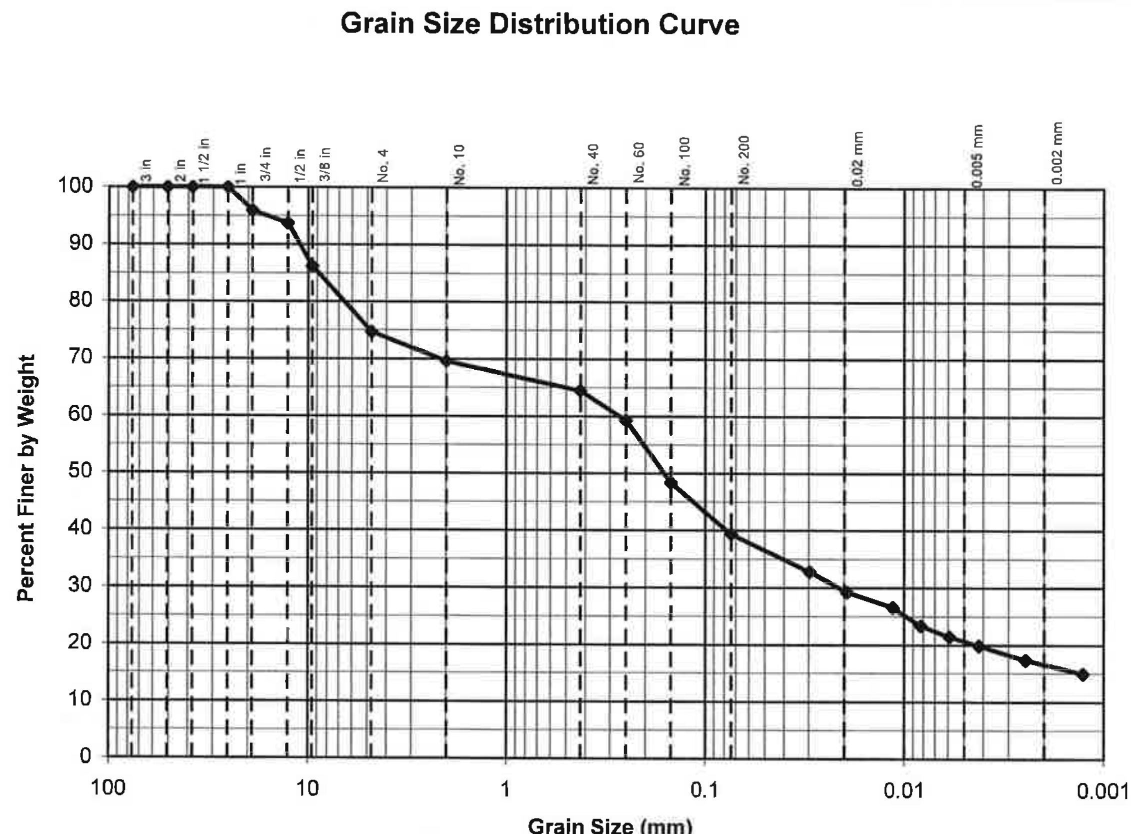

GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
25.3 %		35.3 %			39.4 %	
4.1 %	21.3 %	5.1 %	5.1 %	25.1 %	18.8 %	20.6 %

USCS

Project:	Ash Basin #6 - Brunner Island	**Soil Type:**	clayey SAND with gravel
Boring No.:	TB-C1		
Station:		**Classification:**	SC, A-4 (0)
Offset:		LL = 23 %	PL = 15 %
Sample No.:	S-3	PI = 8 %	w = 14.7 %
Depth:	4.0 - 6.0 ft	**Spec. Grav.:**	2.65 (assumed)

ote: Minimum mass requirement was not met. Mass used for the test = 237.85 grams

GTS TECHNOLOGIES

CLASSIFICATION TEST RESULTS

AASHTO T-88, T-89, T-90, M-145
or ASTM D 422, D 4318, D 2487
10/5/2011

GTS No. 11001-37

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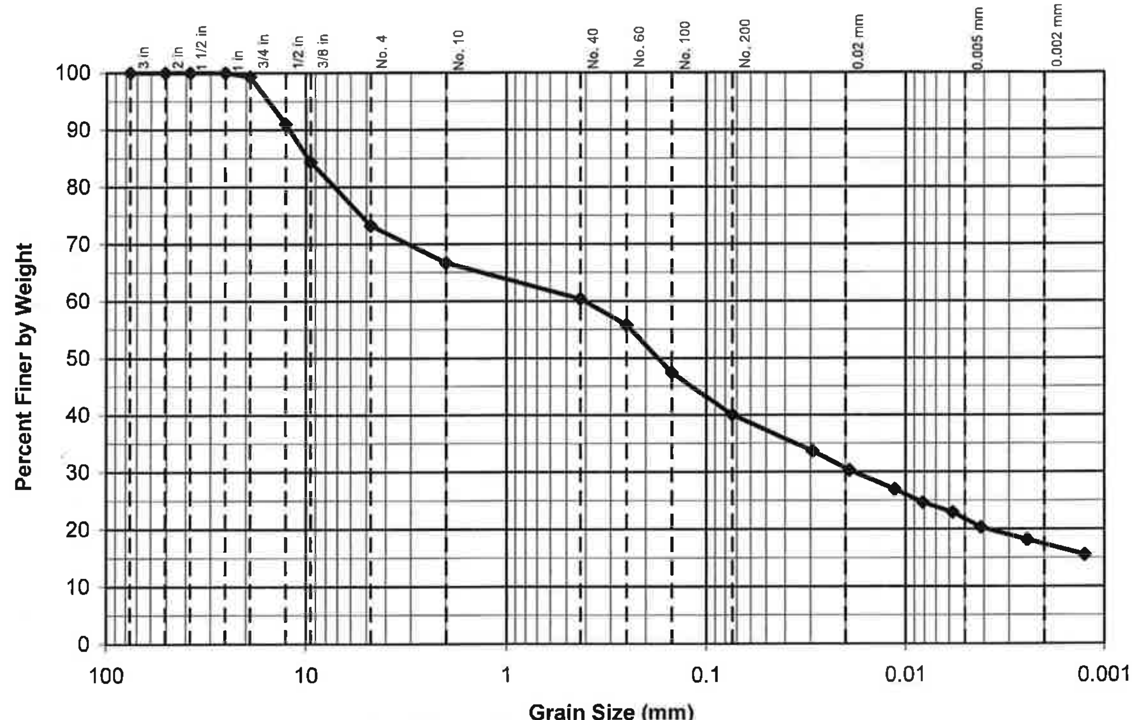
Grain Size Distribution Curve



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
26.8 %		33.2 %			40.0 %	
0.7 %	26.1 %	6.6 %	6.3 %	20.3 %	18.4 %	21.7 %

USCS

Project: Ash Basin #6 - Brunner Island
Boring No.: TB-C1

Sample No.: B-1
Depth: 0.0 - 5.0 ft

Moisture Content: w = 10.6 %

GTS TECHNOLOGIES

GRADATION TEST RESULTS
AASHTO T-88
or ASTM 422
10/5/2011

GTS No. 11001-37 By: DFS Ckd: MCM

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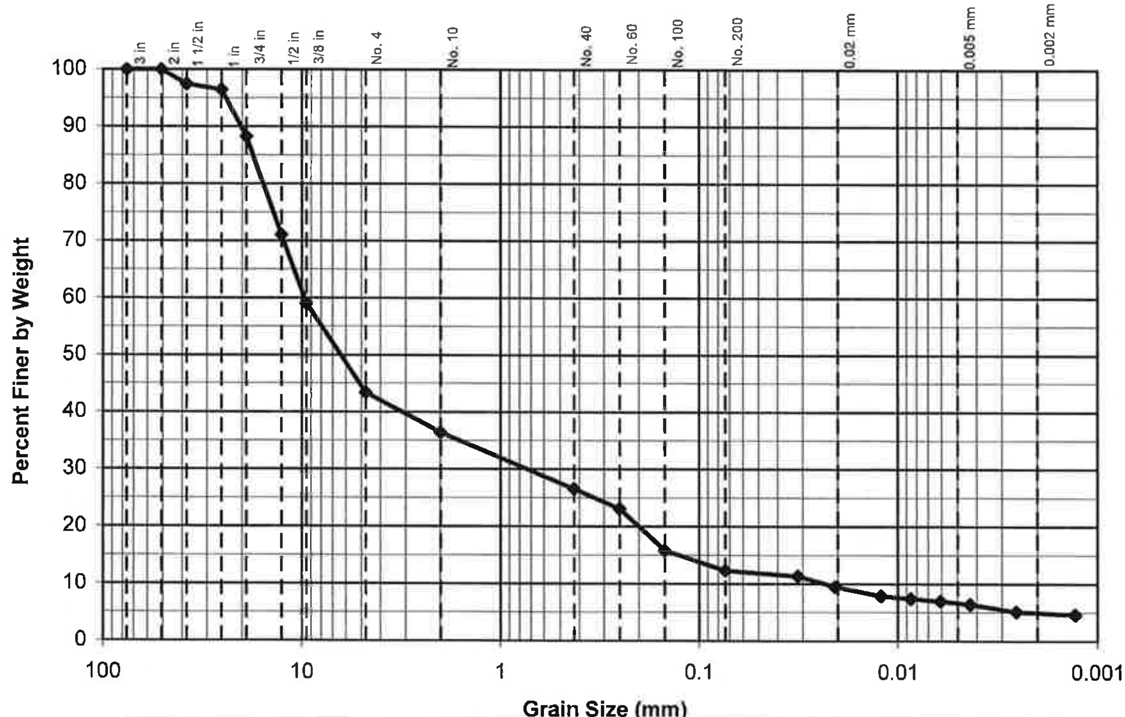
Grain Size Distribution Curve



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
56.6 %		31.1 %			12.3 %	
11.7 %	44.9 %	7.0 %	9.8 %	14.3 %	5.7 %	6.6 %

USCS

Project: Ash Basin #6 - Brunner Island
Boring No.: HA-E4

Sample No.: B-1
Depth: 1.5 - 2.5 ft

Moisture Content: w = 7.3 %

GTS TECHNOLOGIES

GRADATION TEST RESULTS
AASHTO T-88
or ASTM 422
10/7/2011

GTS No. 11001-37

By: DFS Ckd: MCM

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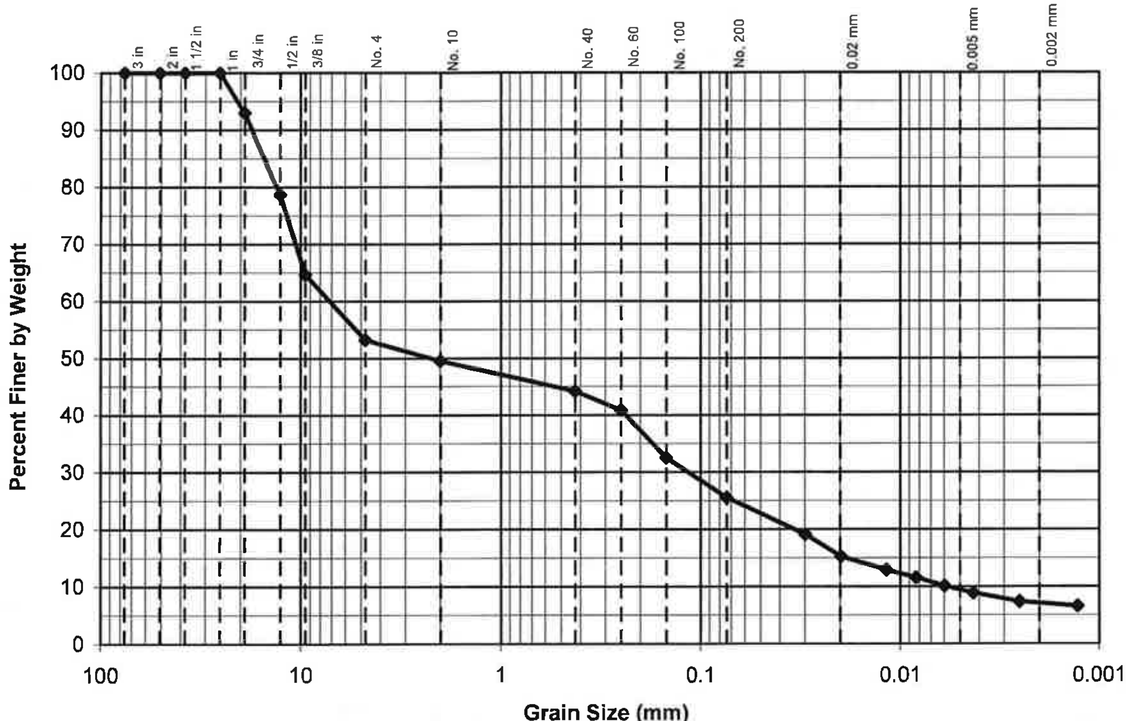
Grain Size Distribution Curve



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
46.8 %		27.6 %			25.6 %	
7.0 %	39.8 %	3.7 %	5.3 %	18.6 %	16.1 %	9.4 %

USCS

Project: Ash Basin #6 - Brunner Island
Boring No.: HA-E3

Sample No.: B-1
Depth: 1.5 - 2.5 ft

Moisture Content: w = 9.5 %

GTS TECHNOLOGIES

GRADATION TEST RESULTS
AASHTO T-88
or ASTM 422
10/7/2011

GTS No. 11001-37

By: DFS Ckd: MCM

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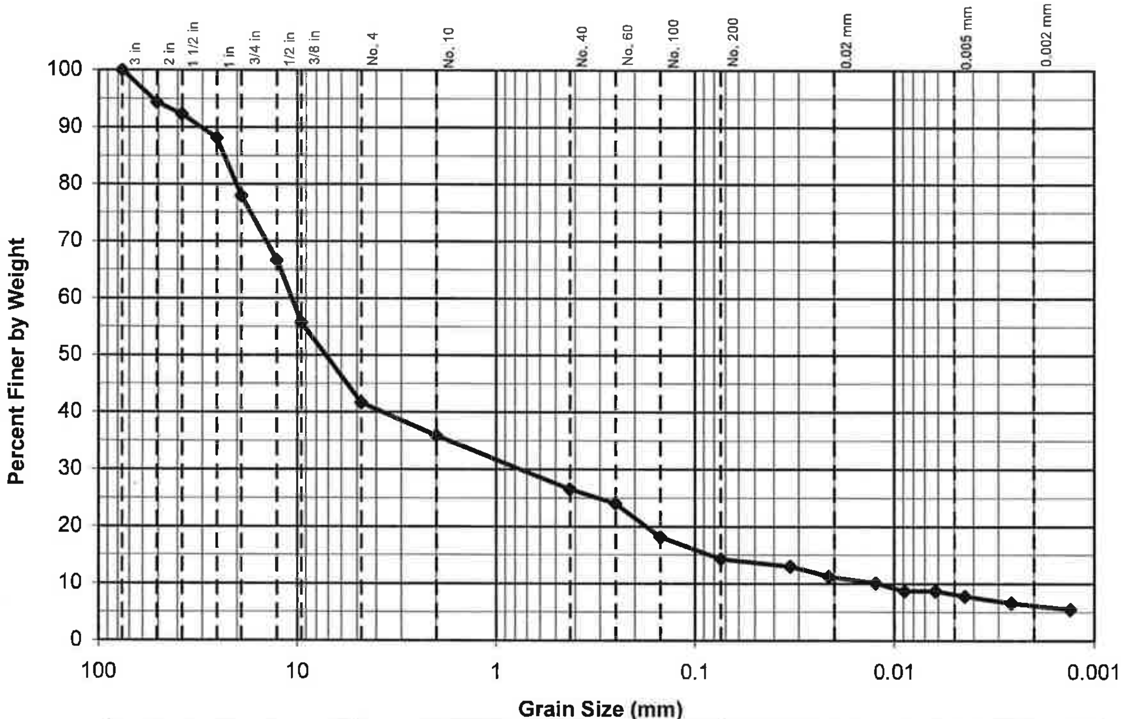
Grain Size Distribution Curve



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
58.4 %		27.3 %			14.4 %	
22.0 %	36.3 %	5.8 %	9.4 %	12.1 %	6.2 %	8.1 %

USCS

Project:	Ash Basin #6 - Brunner Island	**Soil Type:**	silty GRAVEL with sand
Boring No.:	HA-E2		
Station:		**Classification:**	GM, A-1-a (0)
Offset:		LL = 19 %	PL = 17 %
Sample No.:	B-1	PI = 2 %	w = 7.2 %
Depth:	1.0 - 2.0 ft	**Spec. Grav.:**	2.65 (assumed)

ote: Minimum mass requirement was not met. Mass used for the test = 2849.54 grams

GTS TECHNOLOGIES

CLASSIFICATION TEST RESULTS

AASHTO T-88, T-89, T-90, M-145
or ASTM D 422, D 4318, D 2487
10/6/2011

GTS No. 11001-37 By: DFS Ckd: MCM

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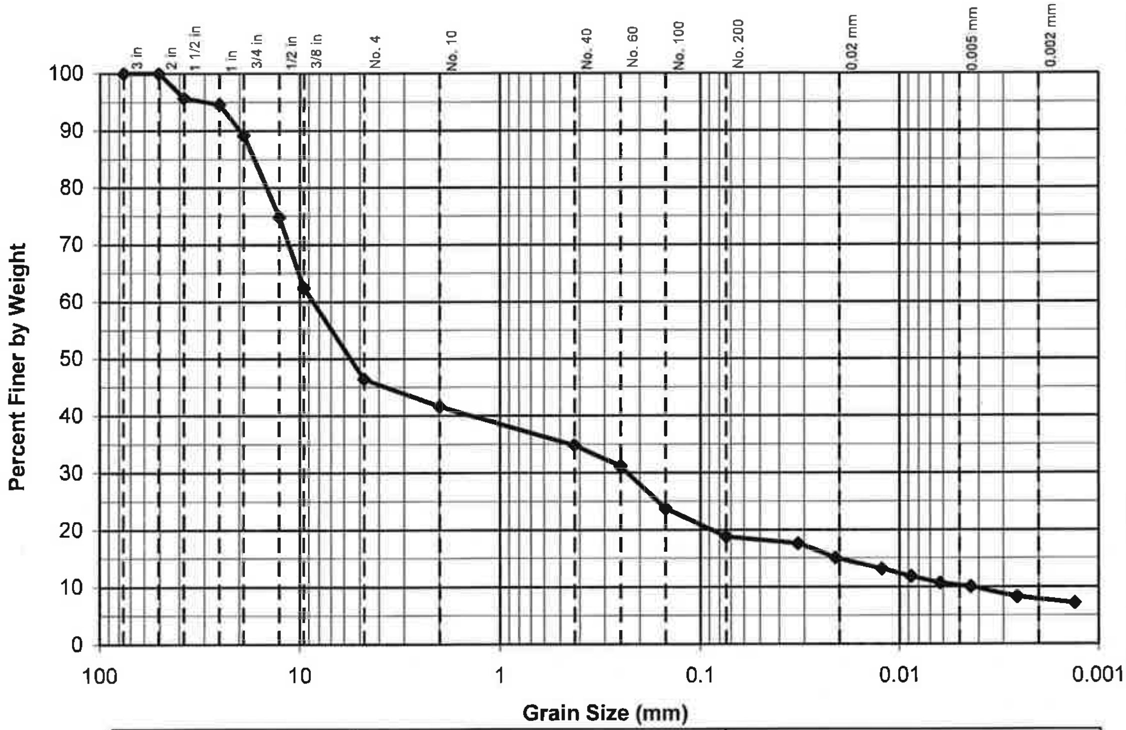
Grain Size Distribution Curve



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
53.5 %		27.6 %			18.8 %	
10.8 %	42.7 %	4.9 %	6.8 %	16.0 %	8.5 %	10.3 %

USCS

Project:	Ash Basin #6 - Brunner Island	**Soil Type:**	silty GRAVEL with sand
Boring No.:	HA-E1		
Station:		**Classification:**	GM, A-1-b (0)
Offset:		LL = 19 %	PL = 17 %
Sample No.:	B-1	PI = 2 %	w = 7.5 %
Depth:	1.0 - 2.0 ft	**Spec. Grav.:**	2.65 (assumed)

ote: Minimum mass requirement was not met. Mass used for the test = 2834.05 grams

GTS TECHNOLOGIES

CLASSIFICATION TEST RESULTS

AASHTO T-88, T-89, T-90, M-145
or ASTM D 422, D 4318, D 2487
10/6/2011

GTS No. 11001-37 By: DFS Ckd: MCM

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Schnabel ENGINEERING

Schnabel Engineering Consultants, Inc.
PPL Ash Basin Brunner Island
Transient Seepage and Slope Stability Study
Addendum No. 1 - Additional Project Data Acquisition
Laboratory Testing Assignments

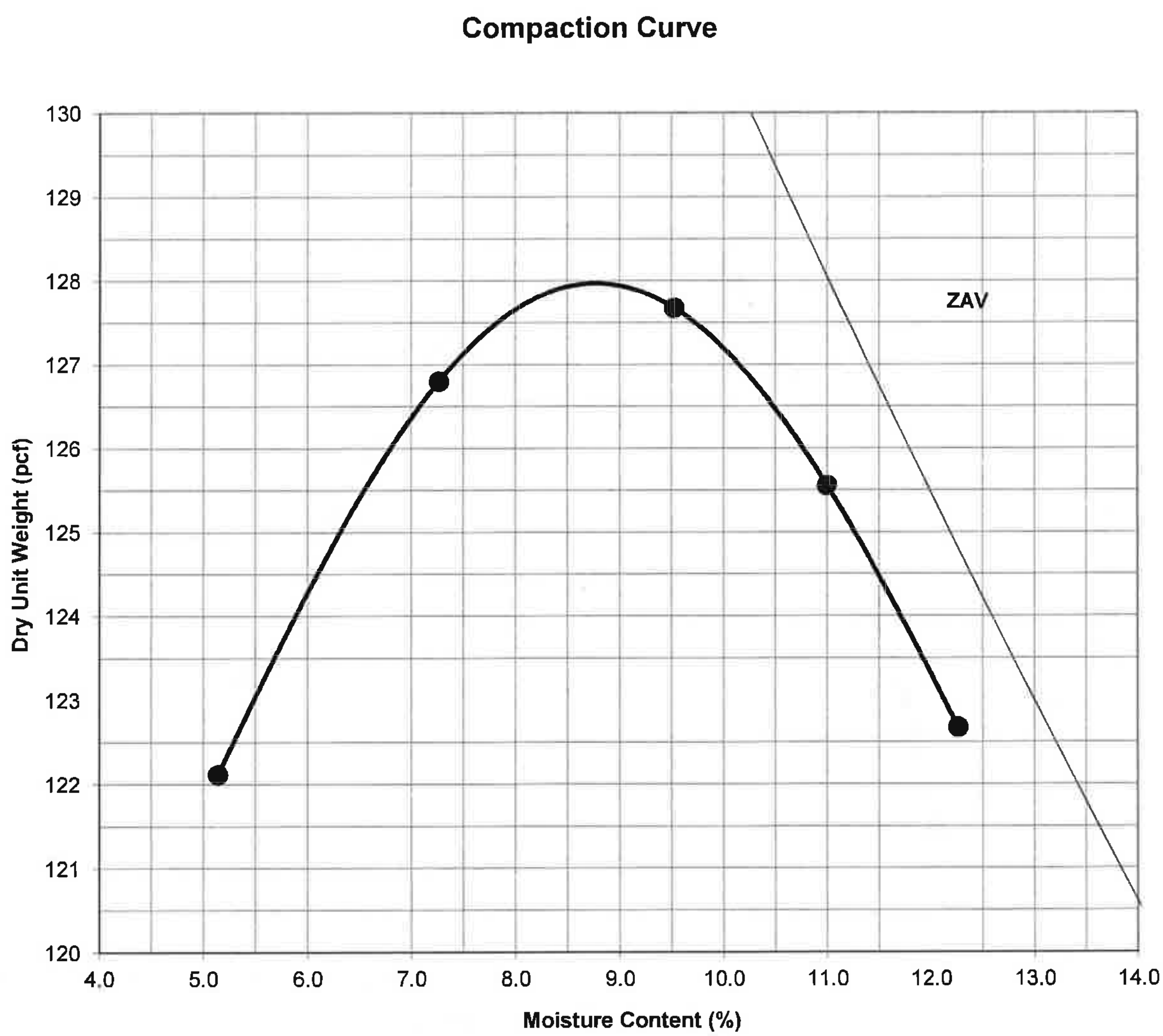
Date: 10/17/2011
By: SAR

Test: Std Proctor (D698)

Depth (ft)	TB-C1		TB-C2		TB-C3		TB-C4		TB-C5	
0										
1	S-1		S-1		S-1		S-1		S-1	
2										
3	S-2	B-1	S-2	B-1	S-2	B-1	S-2	B-1	S-2	B-1
4		Proctor "B"								
5	S-3		S-3		S-3		S-3		S-3	
6										
7	S-4		S-4		S-4		S-4		S-4	
8		B-2		B-2		B-2		B-2		B-2
9	S-5		S-5		S-5		S-5		S-5	
10										
11	S-6		S-6		S-6		S-6		S-6	
12										
13	S-7	B-3	S-7	B-3	S-7	B-3	S-7	B-3	S-7	B-3
14				Proctor "C"						
15	S-8		S-8		S-8		S-8		S-8	
16										
17	S-9		S-9		S-9		S-9		S-9	
18		B-4		B-4		B-4		B-4		B-4
19	S-10		S-10		S-10		S-10		S-10	
20										

S-1, etc (split spoon samples)
B-1, etc (bulk samples from auger cuttings)

Depth (ft)	HA-E1	HA-E2	HA-E3	HA-E4
0				
1				
2	B-1	[illegible]	B-1	B-1
3				
4				
5				



Project:	Brunner Island - Ash Basin #6		
Boring No.:	TB-C1		
Station:			
Offset:			
Sample No.:	B-1	**Max. Dry Density:**	128.0 pcf
Depth:	0.0 - 5.0 ft	**Opt. Moisture:**	8.8 %

GTS TECHNOLOGIES

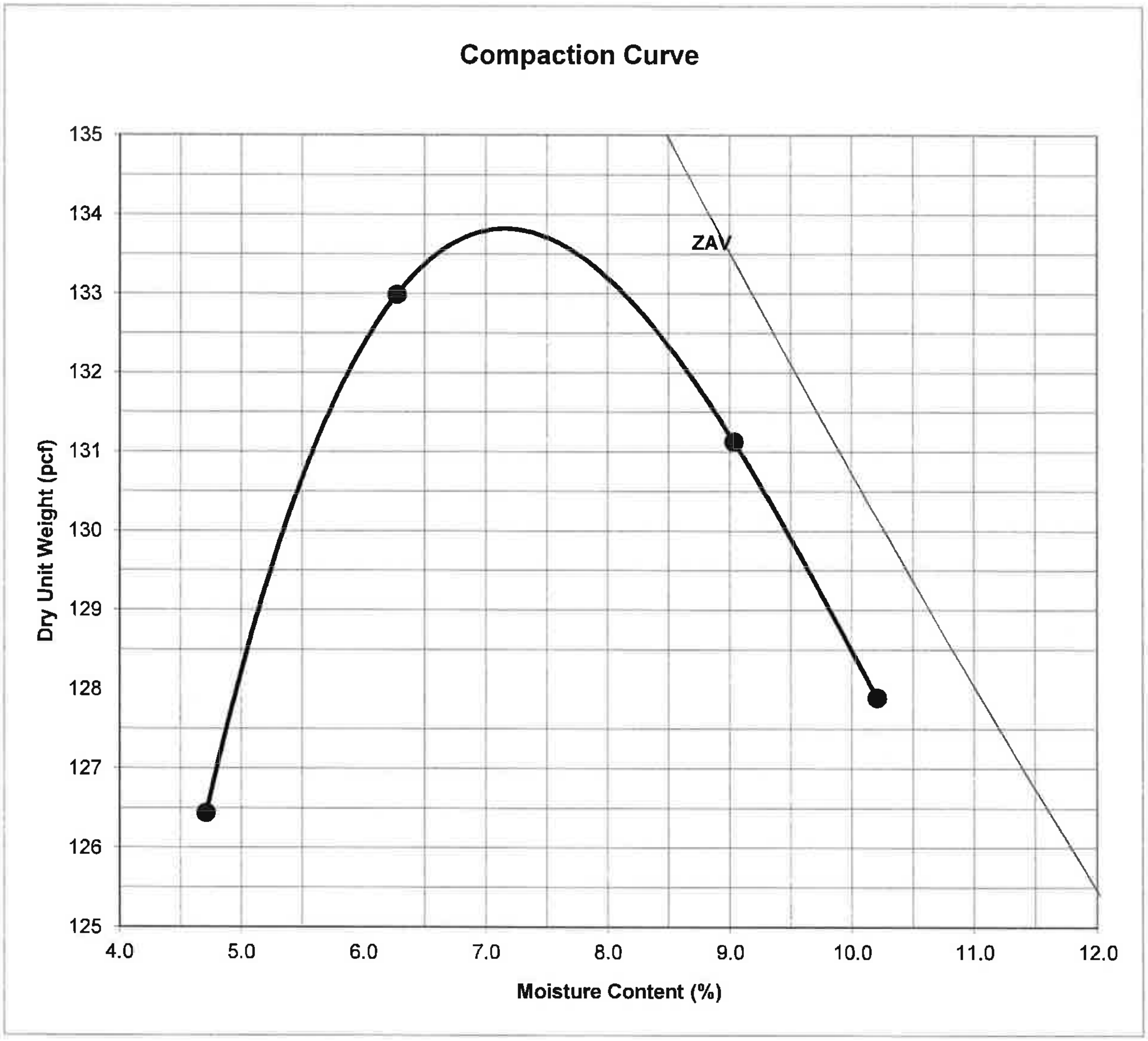
STANDARD PROCTOR COMPACTION TEST RESULTS

AASHTO T-99 or ASTM D-698

10/25/2011

AASHTO R18

GTS No. 11001-37 By: DFS Ckd: dsc



Project:	Brunner Island - Ash Basin #6		
Boring No.:	TB-C2		
Station:			
Offset:			
Sample No.:	B-3	**Max. Dry Density:**	133.8 pcf
Depth:	10.0 - 15.0 ft	**Opt. Moisture:**	7.2 %

GTS TECHNOLOGIES

STANDARD PROCTOR COMPACTION TEST RESULTS

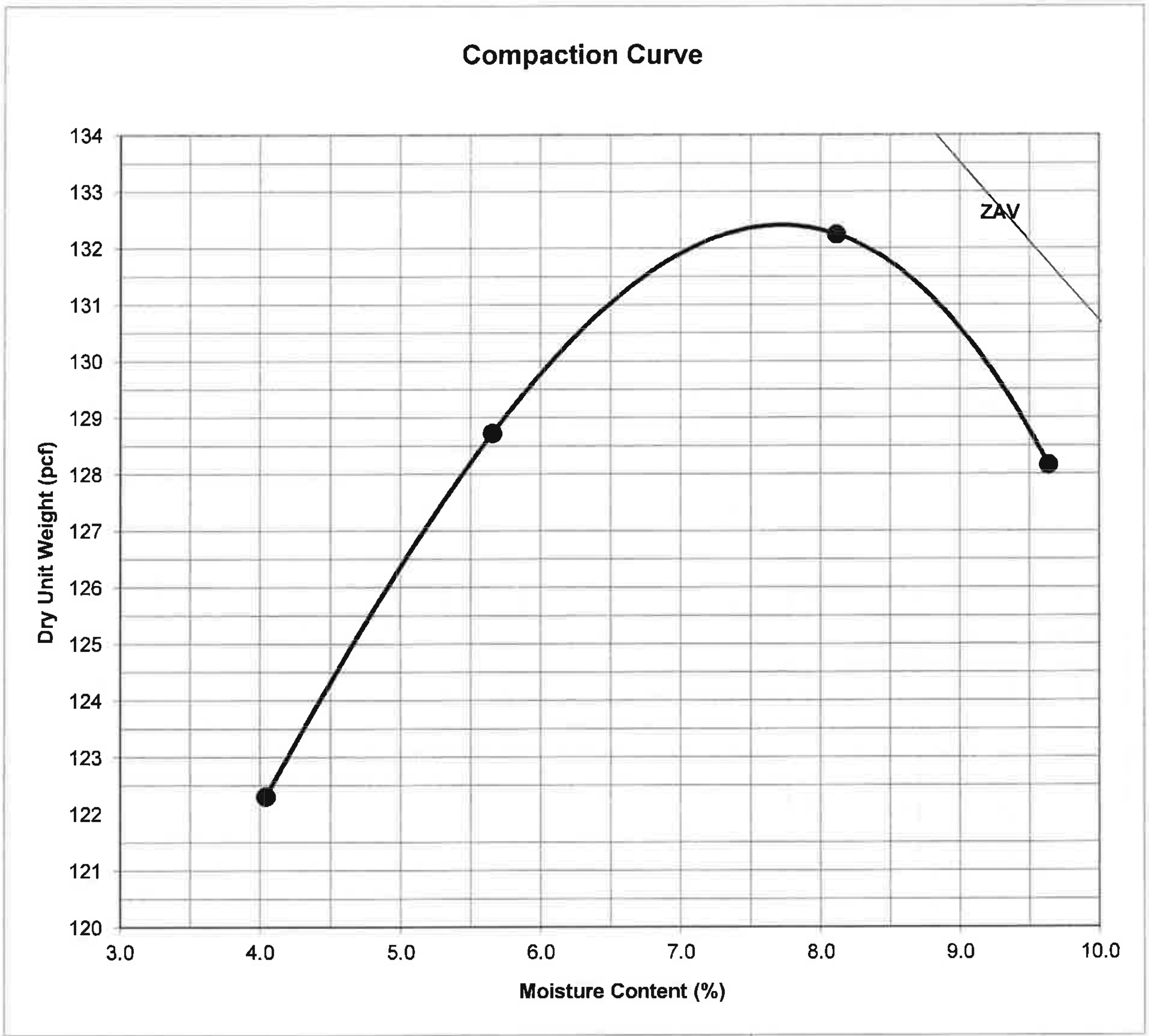
AASHTO T-99 or ASTM D-698

10/27/2011

AASHTO R18

GTS No. 11001-37

By: KJE Ckd: dsc



Project:	Brunner Island - Ash Basin #6			
Boring No.:	HA-E2			
Sample No.:	B-1		**Max. Dry Density:**	132.4 pcf
Depth:	1.0 - 3.0 ft		**Opt. Moisture:**	7.7 %

GTS TECHNOLOGIES

STANDARD PROCTOR COMPACTION TEST RESULTS

AASHTO T-99 or ASTM D-698

10/27/2011

AASHTO R18

GTS No. 11001-37

By: KJE Ckd: dsc

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Schnabel ENGINEERING

Schnabel Engineering Consultants, Inc.
PPL Ash Basin Brunner Island
Transient Seepage and Slope Stability Study
Addendum No. 1 - Additional Project Data Acquisition
Laboratory Testing Assignments

Date: 10/17/2011
By: SAR

Test: Hydraulic Conductivity/Permeability (D2434/5084/5856)

Depth (ft)	TB-C1		TB-C2		TB-C3		TB-C4		TB-C5	
0										
1	S-1		S-1		S-1		S-1		S-1	
2										
3	S-2	B-1	S-2	B-1	S-2	B-1	S-2	B-1	S-2	B-1
4		Perm A								Perm E
5	S-3		S-3		S-3		S-3		S-3	
6										
7	S-4		S-4		S-4		S-4		S-4	
8		B-2		B-2		B-2		B-2		B-2
9	S-5		S-5		S-5	Perm C	S-5	Perm D	S-5	
10										
11	S-6		S-6		S-6		S-6		S-6	
12										
13	S-7	B-3	S-7	B-3	S-7	B-3	S-7	B-3	S-7	B-3
14				Perm B						
15	S-8		S-8		S-8		S-8		S-8	
16										
17	S-9		S-9		S-9		S-9		S-9	
18		B-4		B-4		B-4		B-4		B-4
19	S-10		S-10		S-10		S-10		S-10	
20										

S-1, etc (split spoon samples)
B-1, etc (bulk samples from auger cuttings)

Depth (ft)	HA-E1	HA-E2	HA-E3	HA-E4
0				
1				
2	B-1	B-1 Perm F	B-1 Perm G	B-1
3				
4				
5				

Table 1 - Permeability Testing

Test ID	Boring/HA Loc	Sample	Description
A	TB-C1	B-1	@ opt w/c; x% Relative Compaction (RC) based on Proctor @
B	TB-C2	B-3	@ opt w/c; x% Relative Compaction (RC) based on Proctor C
C	TB-C3	B-2	@ opt w/c; x% Relative Compaction (RC) based on Proctor @
D	TB-C4	B-2	@ opt w/c; x% Relative Compaction (RC) based on Proctor Y - perform supplemental sieve (only - no hydromete
E	TB-C5	B-1	@ opt w/c; x% Relative Compaction (RC) based on Proctor Y - perform supplemental sieve (only - no hydromete
F	HA-E2	B-1	w/c = 9.6%; dry unit weight = 107.5 pcf
G	HA-E3	B-1	w/c = 8.5%; dry unit weight = 117.5 pcf

Note D2434 not appropriate for these soil samples (all greater than 10% fines)

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STANDARD TEST METHOD FOR MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER

ASTM DESIGNATION: D 5084

Test Specimen Data

Sample Type:	Remold	Unified Classification:	
Water Content:	8.9 %	Saturation:	45.0 %
Dry Density:	108.9 pcf	Diameter:	4.00 in
Void Ratio:	.5186	Height:	4.584 in

Test Results

Consolidation Pressure:	10.00 psi	Height:	4.543 in
Cell Pressure:	65 psi	Water Content:	19.1 %
Back Pressure:		Dry Density:	109.9 pcf
At bottom of specimen:	59 psi	Void Ratio:	.5050
At top of specimen:	55 psi	Saturation:	100.0 %
Hydraulic Gradient:	23.4		

PERMEABILITY: 6.69 x 10^{-6} cm/sec

Sample No.: TB-C1 B-1

Sample Description: Brown Sandy Silt and Gravel

Source: TB-C1 B-1

Remarks: Sample compacted to 85.0% Standard Proctor Density at a moisture content of 8.9%

Project No.: 9339.ZA
Brunner Island - Ash Basin No.6
York County, PA
November 17, 2011

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ASTM DESIGNATION: D 5084

Test Specimen Data

Sample Type:	Remold	Unified Classification:	
Water Content:	7.3 %	Saturation:	42.6 %
Dry Density:	113.7 pcf	Diameter:	4.00 in
Void Ratio:	.4545	Height:	4.584 in

Test Results

Consolidation Pressure:	10.00 psi	Height:	4.535 in
Cell Pressure:	65 psi	Water Content:	16.6 %
Back Pressure:		Dry Density:	114.9 pcf
At bottom of specimen:	59 psi	Void Ratio:	.4389
At top of specimen:	55 psi	Saturation:	100.0 %
Hydraulic Gradient:	23.4		

PERMEABILITY: 6.98 x 10^{-5} cm/sec

Sample No.: TB-C2 B-3

Sample Description: Brown Silty Sand and Gravel

Source: TB-C2 B-3

Remarks: Sample compacted to 85.0% Standard Proctor Density at a moisture content of 7.3%

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STANDARD TEST METHOD FOR MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER

ASTM DESIGNATION: D 5084

Test Specimen Data

Sample Type:	Remold	Unified Classification:	
Water Content:	8.8 %	Saturation:	45.0 %
Dry Density:	108.9 pcf	Diameter:	4.00 in
Void Ratio:	.5186	Height:	4.584 in

Test Results

Consolidation Pressure:	10.00 psi	Height:	4.548 in
Cell Pressure:	65 psi	Water Content:	18.9 %
Back Pressure:		Dry Density:	110.1 pcf
At bottom of specimen:	59 psi	Void Ratio:	.5015
At top of specimen:	55 psi	Saturation:	100.0 %
Hydraulic Gradient:	22.0		

PERMEABILITY: 1.87 x 10^{-4} cm/sec

Sample No.: TB-C3 B-2

Sample Description: Brown Silty Sand and Gravel

Source: TB-C3 B-2

Remarks: Sample compacted to 85.0% Standard Proctor Density at a moisture content of 8.8%

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York County, PA
November 18, 2011

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STANDARD TEST METHOD FOR
MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER

ASTM DESIGNATION: D 5084

Test Specimen Data

Sample Type:	Remold	Unified Classification:	
Water Content:	7.1 %	Saturation:	41.4 %
Dry Density:	113.7 pcf	Diameter:	4.00 in
Void Ratio:	.4545	Height:	4.584 in

Test Results

Consolidation Pressure:	10.00 psi	Height:	4.551 in
Cell Pressure:	65 psi	Water Content:	16.8 %
Back Pressure:		Dry Density:	114.5 pcf
At bottom of specimen:	59 psi	Void Ratio:	.4440
At top of specimen:	55 psi	Saturation:	100.0 %
Hydraulic Gradient:	23.4		

PERMEABILITY: 5.68 x 10^{-6} cm/sec

Sample No.: TB-C4 B-2

Sample Description: Brown Sandy Silt and Gravel

Source: TB-C4 B-2

Remarks: Sample compacted to 85.0% Standard Proctor Density at a moisture content of 7.1%

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York County, PA
November 21, 2011

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ASTM DESIGNATION: D 5084

Test Specimen Data

Sample Type:	Remold	Unified Classification:	
Water Content:	9.1 %	Saturation:	46.5 %
Dry Density:	108.9 pcf	Diameter:	4.00 in
Void Ratio:	.5186	Height:	4.584 in

Test Results

Consolidation Pressure:	10.00 psi	Height:	4.548 in
Cell Pressure:	65 psi	Water Content:	19.1 %
Back Pressure:		Dry Density:	109.8 pcf
At bottom of specimen:	59 psi	Void Ratio:	.5066
At top of specimen:	55 psi	Saturation:	100.0 %
Hydraulic Gradient:	22.5		

PERMEABILITY: 8.11 x 10^{-5} cm/sec

Sample No.: TB-C5 B-1

Sample Description: Brown Silty Sand and Gravel

Source: TB-C5 B-1

Remarks: Sample compacted to 85.0% Standard Proctor Density at a moisture content of 9.1%

Project No.: 9339.ZA
Brunner Island - Ash Basin No.6
York County, PA
November 17, 2011

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ASTM DESIGNATION: D 5084

Test Specimen Data

Sample Type:	Remold	**Unified Classification:**	
Water Content:	8.5 %	**Saturation:**	97.5 %
Dry Density:	117.5 pcf	**Diameter:**	4.00 in
Void Ratio:	.4062	**Height:**	4.584 in

Test Results

Consolidation Pressure:	1.44 ksf	**Height:**	4.551 in
Cell Pressure:	65 psi	**Water Content:**	14.9 %
Back Pressure:		**Dry Density:**	118.4 pcf
At bottom of specimen:	59 psi	**Void Ratio:**	.3961
At top of specimen:	55 psi	**Saturation:**	100.0 %
Hydraulic Gradient:	24.4		

PERMEABILITY: 7.06 x 10^{-7} cm/sec

Sample No.: HA E3 B-1

Sample Description: Brown Silty Sand

Source: HA E3 B-1

Remarks: Sample compacted to 117.5 pcf Dry Density at a moisture content of 8.5%.

Project No.: 9339.ZA
Brunner Island - Ash Basin No. 6
York County, Pennsylvania
December 2, 2011

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STANDARD TEST METHOD FOR
MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS
MATERIALS USING A FLEXIBLE WALL PERMEAMETER

ASTM DESIGNATION: D 5084

Test Specimen Data

Sample Type:	Remold	Unified Classification:	
Water Content:	9.6 %	Saturation:	98.5 %
Dry Density:	107.5 pcf	Diameter:	4.00 in
Void Ratio:	.5398	Height:	4.584 in

Test Results

Consolidation Pressure:	1.44 ksf	Height:	4.560 in
Cell Pressure:	65 psi	Water Content:	20.1 %
Back Pressure:		Dry Density:	107.9 pcf
At bottom of specimen:	59 psi	Void Ratio:	.5317
At top of specimen:	55 psi	Saturation:	100.0 %
Hydraulic Gradient:	23.4		

PERMEABILITY: 2.06 x 10^{-7} cm/sec

Sample No.: HA E2 B-1

Sample Description: Brown Sandy Silt

Source: HA E2 B-1

Remarks: Sample compacted to 107.5 pcf Dry Density at a moisture content of 9.6%.

Project No.: 9339.ZA
Brunner Island - Ash Basin No. 6
York County, Pennsylvania
December 2, 2011

APPENDIX B

SUMMARY OF SATURATED HYDRAULIC CONDUCTIVITY DATA

Schnabel Project No. 11615019
Brunner Island AB No. 6 Transient Seepage Analysis
Saturated Hydraulic Conductivity Evaluation

Table 1 - In-Situ (Field) Hydraulic Conductivity Values from Measured Infiltration Rates

Location	Sample No.	Depth (ft bgs)	Test Method								Infiltration Rate (in/hr)	Infiltration Rate (cm/sec)	Infiltration Rate (sec/m)	Sat. Hyd Cond, K (m/sec)	Sat. Hyd Cond, K (ft/sec)	Sat. Hyd Cond, K (cm/sec)
TB-C1	n/a	8	Case-Pipe								1.08	7.62E-04	1.31E+05	1.33E-06	4.35E-06	1.33E-04
TB-C2	n/a	5	Case-Pipe								0.6	4.23E-04	2.36E+05	1.11E-06	3.63E-06	1.11E-04
TB-C3	n/a	8	Case-Pipe								4.68	3.30E-03	3.03E+04	2.09E-06	6.84E-06	2.09E-04
TB-C4	n/a	4	Case-Pipe								0.36	2.54E-04	3.94E+05	9.44E-07	3.10E-06	9.44E-05
TB-C5	n/a	4.5	Case-Pipe								(1)					
HA-E1	n/a	2	Double Ring								0.2	1.41E-04	7.09E+05	7.87E-07	2.58E-06	7.87E-05
HA-E2	n/a	2	Double Ring								0.84	5.93E-04	1.69E+05	1.23E-06	4.03E-06	1.23E-04
HA-E3	n/a	2.25	Double Ring								0.31	2.19E-04	4.57E+05	9.02E-07	2.96E-06	9.02E-05
HA-E4	n/a	2.5	Double Ring								0.25	1.76E-04	5.67E+05	8.44E-07	2.77E-06	8.44E-05
MAX															***6.84E-06***	***2.09E-04***
AVG															***3.78E-06***	***1.15E-04***
MIN															***2.58E-06***	***7.87E-05***

(1) Not measureable

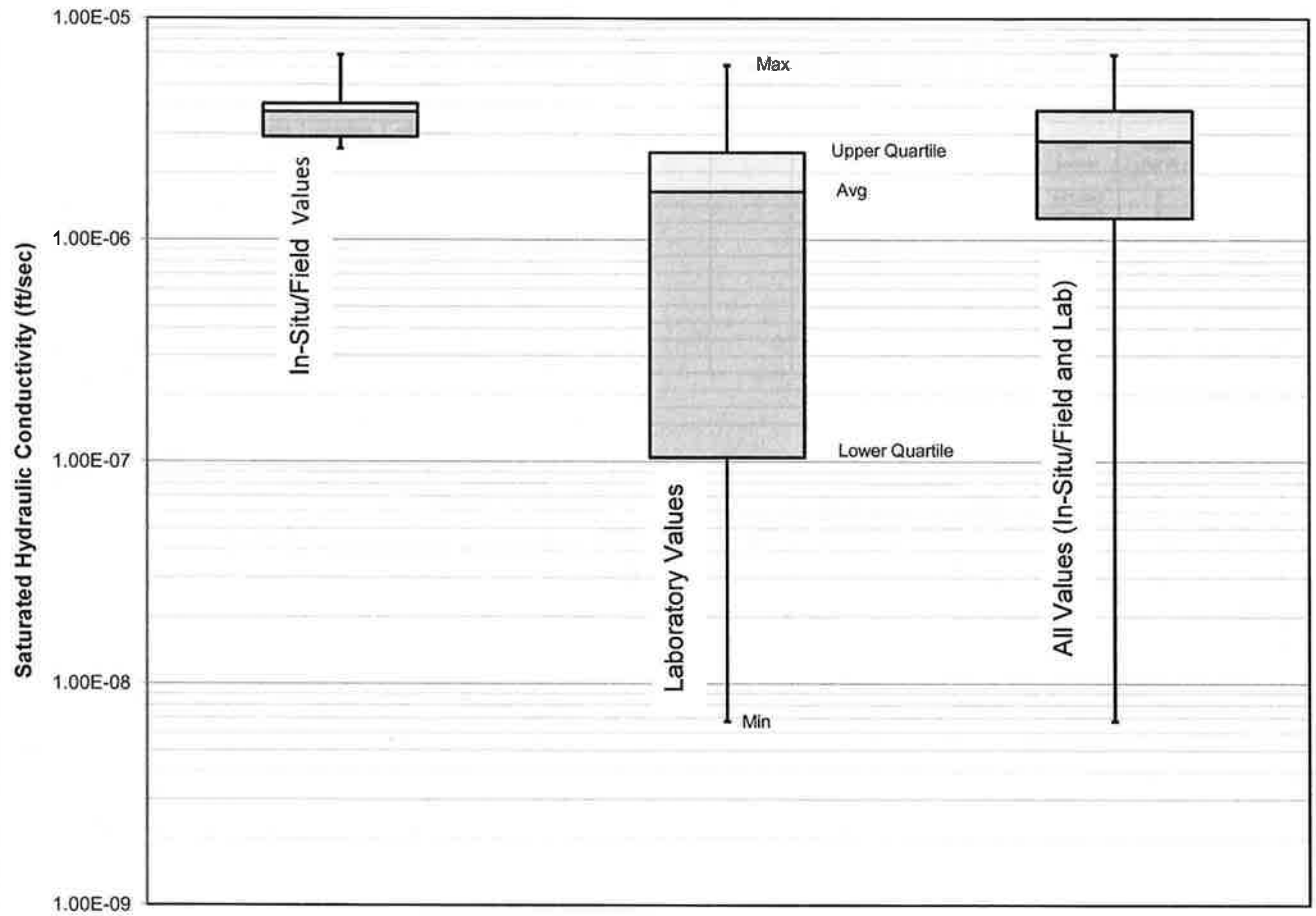
Table 2 - Laboratory Hydraulic Conductivity Measured Values

	Sample No.	Depth (ft bgs)	USCS	% Passing # 200	Initial Specimen Saturation, S (%)	Initial Specimen Moist. Content, m (%)	Initial Specimen Dry Unit Wt, γ_d (pcf)	Initial Specimen Moist Unit Wt, γ_w (pcf)	Initial Specimen Void Ratio, e	Final Specimen Saturation, S (%)	Final Specimen Moist. Content, m (%)	Final Specimen Dry Unit Wt, γ_d (pcf)	Final Specimen Moist (Sat) Unit Wt, γ_w (pcf)	Final Specimen Void Ratio, e	Sat. Hyd Cond, K (ft/sec)	Sat. Hyd Cond, K (cm/sec)
HA-E2	B-1	0-5	GM	14.4	98.5	9.6	107.5	117.8	0.540	100	20.1	107.9	129.6	0.532	6.76E-09	2.06E-07
HA-E3	B-1	0-5	GM/C	25.6	97.5	8.5	117.5	127.5	0.406	100	14.9	118.4	136.0	0.396	2.32E-08	7.06E-07
TB-C1	B-1	0-5	SM/C	40.0	45.0	8.9	108.9	118.6	0.519	100	19.1	109.9	130.9	0.505	2.19E-07	6.69E-06
TB-C2	B-3	10-15	GM/C	23.2	42.6	7.3	113.7	122.0	0.455	100	16.6	114.9	134.0	0.439	2.29E-06	6.98E-05
TB-C3	B-2	5-10	SM/C	36.2	45.0	8.8	108.9	118.5	0.519	100	18.9	110.1	130.9	0.502	6.14E-06	1.87E-04
TB-C4	B-2	5-10	GM/C	23.9	41.4	7.1	113.7	121.8	0.455	100	16.8	114.5	133.7	0.444	1.86E-07	5.68E-06
TB-C5	B-1	0-5	SM/C	33.1	46.5	9.1	108.9	118.8	0.519	100	19.1	109.8	130.8	0.507	2.66E-06	8.11E-05
MAX				***40.0***	***98.5***	***9.6***	***117.5***	***127.5***	***0.540***	***100.0***	***20.1***	***118.4***	***136.0***	***0.532***	***6.14E-06***	***1.87E-04***
AVG				***28.1***	***59.5***	***8.5***	***111.3***	***120.7***	***0.487***	***100.0***	***17.9***	***112.2***	***132.3***	***0.475***	***1.65E-06***	***5.02E-05***
MIN				***14.4***	***41.4***	***7.1***	***107.5***	***117.8***	***0.406***	***100.0***	***14.9***	***107.9***	***129.6***	***0.396***	***6.76E-09***	***2.06E-07***

ALL DATA:

MAX		***6.84E-06***	***2.09E-04***
AVG		***2.79E-06***	***8.49E-05***
MIN		***6.76E-09***	***2.06E-07***

Figure 1 - Box Plot Showing Saturated Hydraulic Conductivity Values



APPENDIX C

SUMMARY OF CLIMATIC, METEORLOGICAL, AND HYDRAULIC CONDUCTIVITY DATA

Hydraulic Analysis of Flood Flows at Brunner Island

Purpose:
Define peak flow frequency curve
Define typical times for rise, high stage, and fall of hydrographs during major floods
Develop precipitation-frequency-duration data

Brunner Island is on the Susquehanna River between two USGS stream gages:

USGS 01570500 Susquehanna River at Harrisburg, PA
LOCATION.--Lat 40`15'17", long 76`53'11", Dauphin County, Hydrologic Unit 02050305, on east bank of City Island, 60 ft downstream from Market Street bridge in Harrisburg, 3,670 ft upstream from sanitary dam, and 1.7 mi upstream from Paxton Creek.
DRAINAGE AREA.--24,100 mi2.
PERIOD OF RECORD.--October 1890 to current year.
GAGE.--Water-stage recorder. Concrete control since Aug. 29, 1916. Datum of gage is 290.01 ft above National Geodetic Vertical Datum of 1929. Prior to Oct. 1, 1928, nonrecording gage at Walnut Street Bridge 600 ft upstream, and Oct. 1, 1928, to Aug. 31, 1975, water-stage recorder at site 3,170 ft downstream, all gages at same datum.
EXTREMES OUTSIDE PERIOD OF RECORD.--Maximum stage known during period 1786 to 1890, 26.8 ft at Walnut Street bridge, June 2, 1889, discharge, 654,000 ft3/s.

USGS 01576000 Susquehanna River at Marietta, PA
LOCATION.--Lat 40`03'16", long 76`31'52", Lancaster County, Hydrologic Unit 02050306, on left bank 420 ft upstream from Chickies Creek, and 1.0 mi downstream from Marietta. Records include flow of Chickies Creek.
DRAINAGE AREA.--25,990 mi2, approximately, includes that of Chickies Creek.
PERIOD OF RECORD.--October 1931 to current year.
GAGE.--Water-stage recorder. Datum of gage is 200.56 ft above sea level.
EXTREMES OUTSIDE PERIOD OF RECORD.--Flood of June 2, 1889, reached a stage of 58.2 ft, from floodmark, discharge, about 630,000 ft3/s.

The site is closer to the Marietta gage and there are no dams between the site and this gage; therefore, the Marietta gage will be used for the analysis.

Peak Flow Frequency Curve

Using the USGS Program PeakFQ, Annual Flood-Frequency Analysis Using Bulletin 17B Guidelines, the following peak flow frequency curve was developed. It was assumed that the 1889 peak flow was an historic peak (but not necessarily the historic peak, as it was recorded by a means prior to establishment of the stream gage in 1932) for the historic period of 111 years, from 1889 to 2010.

The results are summarized below and compared with the peak flows contained in the Lancaster Flood Insurance Study. Because the results compare relatively well, the peak elevations shown in the IFS will be used.

ANNUAL EXCEEDANCE PROBABILITY	Percent Chance	Return period	BULL.17B ESTIMATE	Lancaster County FIS	
				Peak Flow	Peak Elevation
			(cfs)	(cfs)	(ft, NAVD 88)
0.995			123,800		
0.99			130,900		
0.95			155,400		
0.9			172,300		
0.8			197,600		
0.6667			227,300		
0.5	50	2-yr	266,800		
0.4292			286,200		
0.2	20	5-yr	379,700		
0.1	10	10-yr	466,700	420,000	270.7
0.04	4	25-yr	591,800		
0.02	2	50-yr	696,500	615,000	276.8
0.01	1	100-yr	811,900	725,000	279.2
0.005	0.5	200-yr	939,300		
0.002	0.2	500-yr	1,129,000	1,100,000	288.8

As shown in the attached peak flow frequency analysis results, the peak of record occurred during Hurricane Agnus in June 1972. The only other storm t exceed the 2 percent chance event occurred in 1936.While causing significant damage elsewhere, Hurricane Diane in October 1955 was less than a 50-percent-chance event on the Susquehanna in this area.

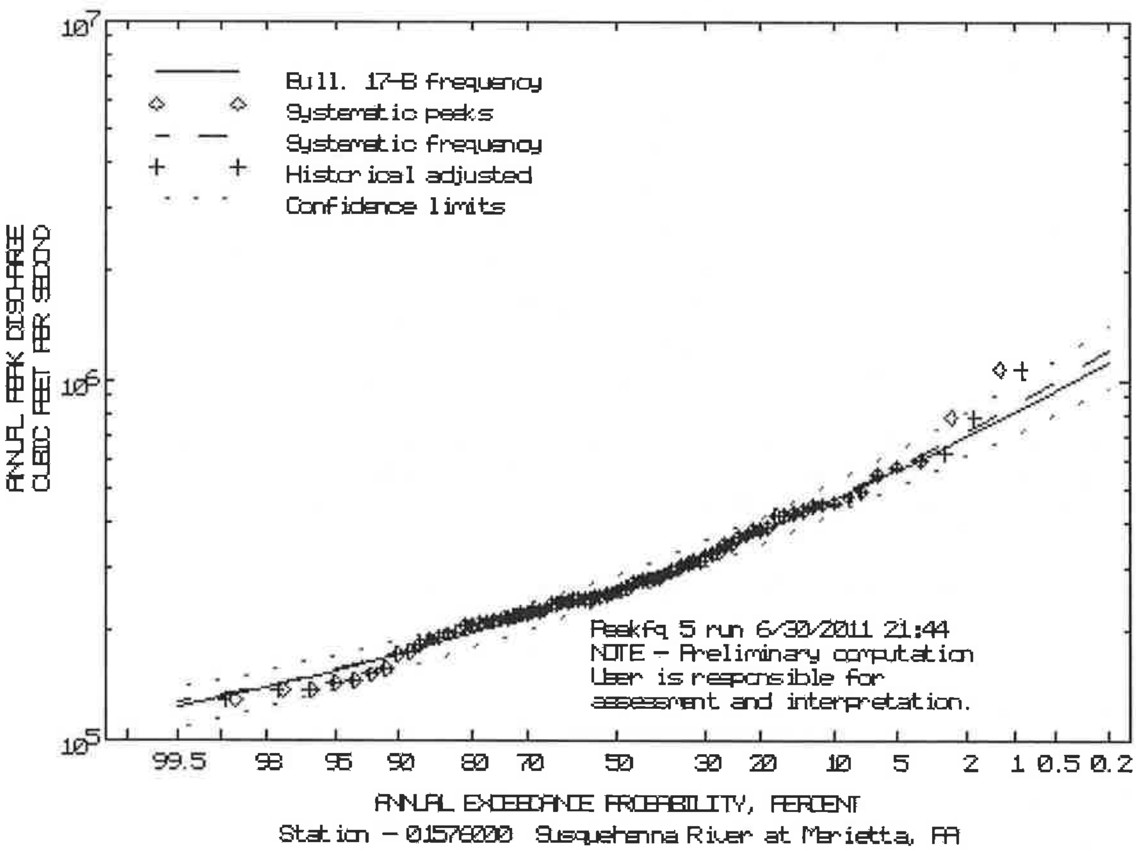
Typical Times for Rise, High Stage, And Fall of Hydrographs During Major Floods

Daily flows for the Marietta gage were observed for the major flood events.

It was found that, for the record storm, Hurricane Agnes in June 1972, the period of rise to the 2 percent chance (50-year) event was about 2 days. The period of high stage above the 2 percent chance event was about 3 days. Using the 50 percent chance (2-year) peak flow to identify the end of the flood event, the period of fall was about 2 days.

Precipitation-Frequency-Duration Data

The attached table shows the results of the precipitation frequency data, developed using NOAA's Atlas 14.



10^7
10^6
10^5
Bull. 17-B frequency
Systematic peaks
Systematic frequency
Historical adjusted
Confidence limits
ANNUAL PEAK DISCHARGE
CUBIC FEET PER SECOND
Peakfq 5 run 6/30/2011 21:44
NOTE - Preliminary computation
User is responsible for
assessment and interpretation.
99.5 98 95 90 80 70 50 30 20 10 5 2 1 0.5 0.2
ANNUAL EXCEEDANCE PROBABILITY, PERCENT
Station - 01576000 Susquehanna River at Marietta, PA

```
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY              Seq.000.000
  Ver. 5.2             Annual peak flow frequency analysis     Run Date / Time
  11/01/2007           following Bulletin 17-B Guidelines      06/30/2011 21:13

                          --- PROCESSING OPTIONS ---

                       Plot option          = None
                       Basin char output    = None
                       Print option         = Yes
                       Debug print          = No
                       Input peaks listing = Long
                       Input peaks format   = WATSTORE peak file

                       Input files used:
                          peaks (ascii)  -
G:\2011-SEC-JOBS\11615019_00-ASH_BASIN_6_SLOPE_STABILITY\DATA\1576000.TXT
                          specifications - PKFQWPSF.TMP

                       Output file(s):
                          main -
G:\2011-SEC-JOBS\11615019_00-ASH_BASIN_6_SLOPE_STABILITY\DATA\1576000.PRT

1


  Program PeakFq          U. S. GEOLOGICAL SURVEY              Seq.001.001
  Ver. 5.2             Annual peak flow frequency analysis     Run Date / Time
  11/01/2007           following Bulletin 17-B Guidelines      06/30/2011 21:13

            Station - 01576000  Susquehanna River at Marietta, PA

                    I N P U T   D A T A   S U M M A R Y

               Number of peaks in record              =       80
               Peaks not used in analysis             =        0
               Systematic peaks in analysis           =       79
               Historic peaks in analysis             =        1
               Years of historic record               =      111
               Generalized skew                       =    0.560
                    Standard error                    =    0.550
                    Mean Square error                 =    0.303
               Skew option                            =   WEIGHTED
               Gage base discharge                    =      0.0
               User supplied high outlier threshold =     --
               User supplied low outlier criterion    =     --
               Plotting position parameter            =     0.00


  *********  NOTICE  --  Preliminary machine computations.         *********
  *********  User responsible for assessment and interpretation.   *********

    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                     0.0
    WCF156I-17B HI-OUTLIER TEST SUPERSEDED BY MIN HIST PK   898061.8
    WCF165I-HIGH OUTLIERS AND HISTORIC PEAKS ABOVE HHBASE.   2  1    630000.3
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.           83347.2
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY              Seq.001.002
  Ver. 5.2             Annual peak flow frequency analysis     Run Date / Time
```

11/01/2007 following Bulletin 17-B Guidelines 06/30/2011 21:13

Station - 01576000 Susquehanna River at Marietta, PA

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE		LOGARITHMIC		
	DISCHARGE	EXCEEDANCE PROBABILITY	MEAN	STANDARD DEVIATION	SKEW
SYSTEMATIC RECORD	0.0	1.0000	5.4428	0.1739	0.672
BULL.17B ESTIMATE	0.0	1.0000	5.4423	0.1709	0.569

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	123800.0	126900.0	121700.0	107100.0	139100.0
0.9900	130900.0	133400.0	129000.0	114100.0	146300.0
0.9500	155400.0	156200.0	154100.0	138200.0	171100.0
0.9000	172300.0	172300.0	171300.0	155000.0	188300.0
0.8000	197600.0	196700.0	197000.0	180200.0	214100.0
0.6667	227300.0	225800.0	227000.0	209500.0	244900.0
0.5000	266800.0	265100.0	266800.0	247700.0	287000.0
0.4292	286200.0	284700.0	286400.0	266000.0	308200.0
0.2000	379700.0	380800.0	381300.0	350700.0	415600.0
0.1000	466700.0	472600.0	471100.0	425600.0	521400.0
0.0400	591800.0	607500.0	602700.0	529000.0	680000.0
0.0200	696500.0	723100.0	715500.0	613100.0	817500.0
0.0100	811900.0	852500.0	842500.0	703800.0	972800.0
0.0050	939300.0	997800.0	986300.0	802100.0	1148000.0
0.0020	1129000.0	1218000.0	1207000.0	945300.0	1416000.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 06/30/2011 21:13

Station - 01576000 Susquehanna River at Marietta, PA

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
-1889	630000.0	H	1971	238000.0	
1932	256000.0		1972	1080000.0	
1933	296000.0		1973	224000.0	
1934	152000.0		1974	218000.0	
1935	263000.0		1975	545000.0	
1936	787000.0		1976	260000.0	
1937	241000.0		1977	283000.0	
1938	176000.0		1978	277000.0	
1939	213000.0		1979	452000.0	
1940	432000.0		1980	220000.0	

1941	249000.0	1981	316000.0
1942	307000.0	1982	207000.0
1943	428000.0	1983	276000.0
1944	211000.0	1984	458000.0
1945	254000.0	1985	137000.0
1946	492000.0	1986	384000.0
1947	214000.0	1987	238000.0
1948	310000.0	1988	200000.0
1949	227000.0	1989	230000.0
1950	298000.0	1990	138000.0
1951	420000.0	1991	216000.0
1952	329000.0	1992	172000.0
1953	227000.0	1993	448000.0
1954	246000.0	1994	365000.0
1955	183000.0	1995	192000.0
1956	325000.0	1996	601000.0
1957	249000.0	1997	277000.0
1958	274000.0	1998	336000.0
1959	241000.0	1999	247000.0
1960	370000.0	2000	224000.0
1961	386000.0	2001	158000.0
1962	265000.0	2002	197000.0
1963	245000.0	2003	289000.0
1964	473000.0	2004	577000.0
1965	129000.0	2005	391000.0
1966	280000.0	2006	421000.0
1967	191000.0	2007	247000.0
1968	208000.0	2008	352000.0
1969	143000.0	2009	146000.0
1970	350000.0	2010	316000.0

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq — U. S. GEOLOGICAL SURVEY — Seq.001.004
Ver. 5.2 — Annual peak flow frequency analysis — Run Date / Time
11/01/2007 — following Bulletin 17-B Guidelines — 06/30/2011 21:13

Station - 01576000 Susquehanna River at Marietta, PA

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER RANKED SYSTEMATIC BULL.17B

YEAR	DISCHARGE	RECORD	ESTIMATE
1972	1080000.0	0.0125	0.0089
1936	787000.0	0.0250	0.0179
-1889	630000.0	---	0.0268
1996	601000.0	0.0375	0.0375
2004	577000.0	0.0500	0.0500
1975	545000.0	0.0625	0.0626
1946	492000.0	0.0750	0.0751
1964	473000.0	0.0875	0.0876
1984	458000.0	0.1000	0.1001
1979	452000.0	0.1125	0.1127
1993	448000.0	0.1250	0.1252
1940	432000.0	0.1375	0.1377
1943	428000.0	0.1500	0.1502
2006	421000.0	0.1625	0.1627
1951	420000.0	0.1750	0.1753
2005	391000.0	0.1875	0.1878
1961	386000.0	0.2000	0.2003
1986	384000.0	0.2125	0.2128
1960	370000.0	0.2250	0.2254
1994	365000.0	0.2375	0.2379
2008	352000.0	0.2500	0.2504
1970	350000.0	0.2625	0.2629
1998	336000.0	0.2750	0.2755
1952	329000.0	0.2875	0.2880
1956	325000.0	0.3000	0.3005
1981	316000.0	0.3125	0.3130
2010	316000.0	0.3250	0.3255
1948	310000.0	0.3375	0.3381
1942	307000.0	0.3500	0.3506
1950	298000.0	0.3625	0.3631
1933	296000.0	0.3750	0.3756
2003	289000.0	0.3875	0.3882
1977	283000.0	0.4000	0.4007
1966	280000.0	0.4125	0.4132
1978	277000.0	0.4250	0.4257
1997	277000.0	0.4375	0.4383
1983	276000.0	0.4500	0.4508
1958	274000.0	0.4625	0.4633
1962	265000.0	0.4750	0.4758
1935	263000.0	0.4875	0.4883
1976	260000.0	0.5000	0.5009
1932	256000.0	0.5125	0.5134
1945	254000.0	0.5250	0.5259
1941	249000.0	0.5375	0.5384
1957	249000.0	0.5500	0.5510
1999	247000.0	0.5625	0.5635
2007	247000.0	0.5750	0.5760
1954	246000.0	0.5875	0.5885
1963	245000.0	0.6000	0.6011
1937	241000.0	0.6125	0.6136
1959	241000.0	0.6250	0.6261
1971	238000.0	0.6375	0.6386
1987	238000.0	0.6500	0.6511
1989	230000.0	0.6625	0.6637
1949	227000.0	0.6750	0.6762
1953	227000.0	0.6875	0.6887
1973	224000.0	0.7000	0.7012
2000	224000.0	0.7125	0.7138
1980	220000.0	0.7250	0.7263
1974	218000.0	0.7375	0.7388
1991	216000.0	0.7500	0.7513

1947	214000.0	0.7625	0.7639
1939	213000.0	0.7750	0.7764
1944	211000.0	0.7875	0.7889
1968	208000.0	0.8000	0.8014
1982	207000.0	0.8125	0.8139
1988	200000.0	0.8250	0.8265
2002	197000.0	0.8375	0.8390
1995	192000.0	0.8500	0.8515
1967	191000.0	0.8625	0.8640
1955	183000.0	0.8750	0.8766
1938	176000.0	0.8875	0.8891
1992	172000.0	0.9000	0.9016
2001	158000.0	0.9125	0.9141
1934	152000.0	0.9250	0.9267
2009	146000.0	0.9375	0.9392
1969	143000.0	0.9500	0.9517
1990	138000.0	0.9625	0.9642
1985	137000.0	0.9750	0.9768
1965	129000.0	0.9875	0.9893

1

```
 End PeakFQ analysis.
   Stations processed :        1
   Number of errors   :        0
   Stations skipped   :        0
   Station years      :       80
```

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 01576000   USGS Susquehanna River at Marietta

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

NOAA Atlas 14, Volume 2, Version 3
Location name: Mt Wolf, Pennsylvania, US*
Coordinates: 40.0999, -76.6967
Elevation: 266ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval(years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.318 (0.287-0.354)	0.379 (0.340-0.421)	0.447 (0.401-0.497)	0.496 (0.444-0.550)	0.556 (0.496-0.616)	0.599 (0.533-0.663)	0.641 (0.568-0.710)	0.680 (0.599-0.753)	0.727 (0.636-0.805)	0.764 (0.664-0.845)
10-min	0.508 (0.458-0.565)	0.605 (0.544-0.674)	0.715 (0.642-0.796)	0.793 (0.711-0.880)	0.887 (0.790-0.982)	0.954 (0.848-1.06)	1.02 (0.903-1.13)	1.08 (0.950-1.19)	1.15 (1.01-1.27)	1.20 (1.05-1.33)
15-min	0.635 (0.572-0.706)	0.761 (0.684-0.847)	0.905 (0.813-1.01)	1.00 (0.899-1.11)	1.12 (1.00-1.25)	1.21 (1.07-1.34)	1.29 (1.14-1.43)	1.36 (1.20-1.51)	1.45 (1.27-1.60)	1.51 (1.31-1.67)
30-min	0.870 (0.784-0.968)	1.05 (0.944-1.17)	1.29 (1.15-1.43)	1.45 (1.30-1.61)	1.67 (1.48-1.84)	1.82 (1.62-2.02)	1.97 (1.75-2.18)	2.12 (1.87-2.35)	2.30 (2.02-2.55)	2.44 (2.13-2.71)
60-min	1.09 (0.978-1.21)	1.32 (1.19-1.47)	1.65 (1.48-1.83)	1.89 (1.70-2.10)	2.22 (1.98-2.46)	2.47 (2.19-2.73)	2.72 (2.41-3.01)	2.97 (2.62-3.29)	3.31 (2.89-3.66)	3.57 (3.10-3.95)
2-hr	1.27 (1.15-1.42)	1.54 (1.39-1.72)	1.96 (1.76-2.17)	2.28 (2.05-2.53)	2.75 (2.45-3.03)	3.13 (2.78-3.45)	3.54 (3.12-3.90)	3.97 (3.47-4.37)	4.59 (3.97-5.06)	5.10 (4.38-5.62)
3-hr	1.39 (1.25-1.55)	1.69 (1.52-1.88)	2.14 (1.93-2.38)	2.50 (2.25-2.78)	3.00 (2.68-3.32)	3.42 (3.03-3.78)	3.87 (3.41-4.27)	4.34 (3.80-4.79)	5.02 (4.34-5.55)	5.57 (4.78-6.17)
6-hr	1.71 (1.54-1.92)	2.07 (1.87-2.32)	2.61 (2.35-2.93)	3.07 (2.74-3.42)	3.73 (3.31-4.14)	4.29 (3.79-4.76)	4.90 (4.29-5.43)	5.57 (4.83-6.16)	6.56 (5.61-7.25)	7.39 (6.24-8.17)
12-hr	2.08 (1.86-2.37)	2.51 (2.24-2.86)	3.18 (2.83-3.62)	3.76 (3.33-4.26)	4.63 (4.07-5.23)	5.39 (4.70-6.07)	6.24 (5.38-7.01)	7.18 (6.13-8.05)	8.61 (7.22-9.64)	9.85 (8.15-11.0)
24-hr	2.39 (2.20-2.63)	2.89 (2.66-3.18)	3.70 (3.39-4.07)	4.40 (4.03-4.83)	5.49 (4.97-5.99)	6.45 (5.80-7.00)	7.53 (6.70-8.14)	8.76 (7.69-9.45)	10.6 (9.19-11.4)	12.3 (10.5-13.2)
2-day	2.77 (2.56-3.06)	3.35 (3.09-3.70)	4.29 (3.94-4.72)	5.09 (4.65-5.59)	6.28 (5.70-6.88)	7.32 (6.59-8.00)	8.48 (7.58-9.24)	9.77 (8.63-10.6)	11.7 (10.2-12.8)	13.4 (11.5-14.6)
3-day	2.95 (2.72-3.24)	3.56 (3.29-3.91)	4.54 (4.19-4.98)	5.38 (4.94-5.90)	6.65 (6.06-7.26)	7.75 (7.01-8.44)	8.98 (8.05-9.76)	10.3 (9.18-11.2)	12.4 (10.8-13.5)	14.2 (12.2-15.4)
4-day	3.12 (2.89-3.41)	3.77 (3.49-4.12)	4.80 (4.44-5.25)	5.68 (5.23-6.21)	7.02 (6.41-7.64)	8.18 (7.42-8.89)	9.47 (8.52-10.3)	10.9 (9.73-11.9)	13.1 (11.5-14.2)	15.0 (13.0-16.3)
7-day	3.66 (3.40-3.98)	4.40 (4.09-4.80)	5.55 (5.14-6.04)	6.53 (6.02-7.09)	7.99 (7.33-8.68)	9.27 (8.44-10.0)	10.7 (9.65-11.6)	12.2 (11.0-13.2)	14.6 (12.9-15.8)	16.6 (14.5-18.0)
10-day	4.20 (3.92-4.54)	5.04 (4.71-5.46)	6.28 (5.85-6.78)	7.31 (6.80-7.89)	8.82 (8.15-9.50)	10.1 (9.28-10.9)	11.5 (10.5-12.3)	13.0 (11.7-13.9)	15.2 (13.5-16.3)	17.0 (15.0-18.3)
20-day	5.72 (5.39-6.10)	6.80 (6.40-7.26)	8.19 (7.71-8.74)	9.33 (8.75-9.95)	10.9 (10.2-11.6)	12.2 (11.4-13.0)	13.6 (12.6-14.4)	15.0 (13.8-15.9)	16.9 (15.5-18.0)	18.5 (16.8-19.8)
30-day	7.07 (6.69-7.51)	8.36 (7.90-8.87)	9.91 (9.36-10.5)	11.2 (10.5-11.8)	12.9 (12.1-13.7)	14.3 (13.4-15.2)	15.7 (14.7-16.7)	17.2 (16.0-18.3)	19.2 (17.7-20.4)	20.8 (19.0-22.2)
45-day	8.90 (8.47-9.37)	10.5 (9.98-11.0)	12.2 (11.6-12.8)	13.6 (12.9-14.3)	15.4 (14.5-16.1)	16.7 (15.8-17.5)	18.1 (17.0-19.0)	19.4 (18.2-20.4)	21.1 (19.8-22.3)	22.5 (20.9-23.7)
60-day	10.6 (10.2-11.2)	12.5 (11.9-13.1)	14.4 (13.7-15.1)	15.9 (15.1-16.6)	17.8 (16.9-18.6)	19.2 (18.2-20.1)	20.5 (19.4-21.6)	21.9 (20.6-23.0)	23.6 (22.2-24.8)	24.8 (23.3-26.1)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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PF graphical

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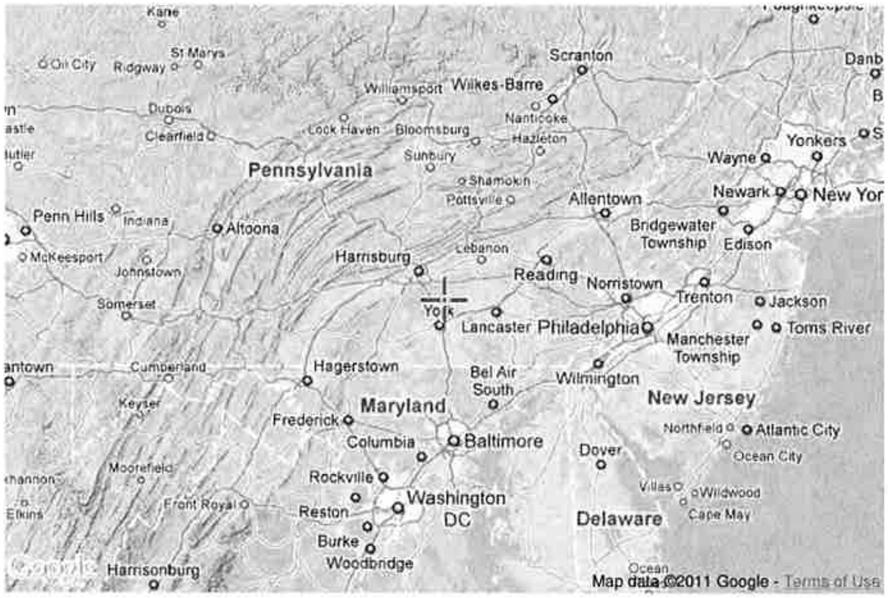
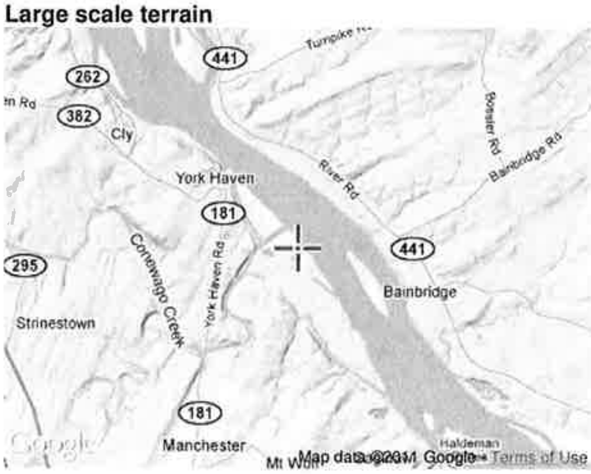
Maps & aerials

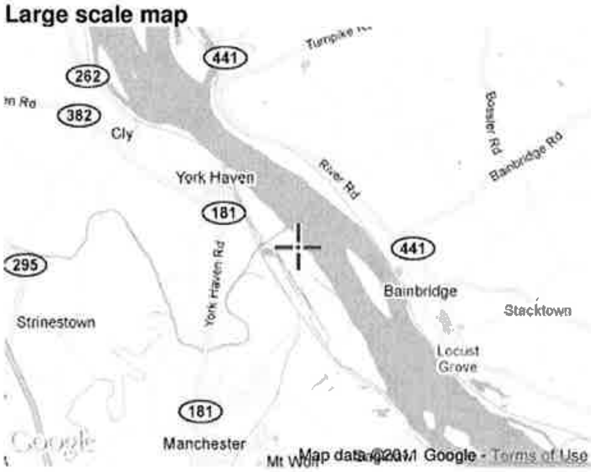
Small scale terrain



Large scale terrain



Large scale map



Large scale aerial

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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Office of Hydrologic Development
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Select Other Date

These data are preliminary and have not undergone final quality control by the National Climatic Data Center (NCDC). Therefore, these data are subject to revision. Final and certified climate data can be accessed at the NCDC - http://www.ncdc.noaa.gov.

Climatological Report (Annual)

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CXUS51 KCTP 021406
CLAMDT

CLIMATE REPORT
NATIONAL WEATHER SERVICE STATE COLLEGE PA
905 AM EST SUN JAN 2 2011

.....................................

...THE HARRISBURG PA CLIMATE SUMMARY FOR THE YEAR OF 2010...

CLIMATE NORMAL PERIOD 1971 TO 2000
CLIMATE RECORD PERIOD 1888 TO 2011

WEATHER          OBSERVED              NORMAL  DEPART
                  VALUE    DATE(S)     VALUE   FROM
                                               NORMAL
...............................................
TEMPERATURE (F)
RECORD
 HIGH              107    07/03/1966
 LOW               -22    01/21/1994

2010...
HIGHEST            100    07/06
LOWEST              13    01/31
AVG. MAXIMUM      64.1                  62.4     1.7
AVG. MINIMUM      46.1                  44.1     2.0
MEAN              55.1                  53.3     1.8
DAYS MAX >= 90      34                  22.4    11.6
DAYS MAX <= 32      20                  19.7     0.3
DAYS MIN <= 32     100                 101.7    -1.7
DAYS MIN <= 0        0                   0.9    -0.9

PRECIPITATION (INCHES)
RECORD
 MAXIMUM         59.27    1972
 MINIMUM         25.52    1941

2010...
```

TOTALS	39.43		41.45	-2.02
DAILY AVG.	0.11		0.11	0.00
DAYS >= .01	100		119.2	-19.2
DAYS >= .10	68		75.0	-7.0
DAYS >= .50	25		25.0	0.0
DAYS >= 1.00	9		9.8	-0.8
GREATEST				
24 HR. TOTAL	3.42			

SNOWFALL (INCHES)

RECORDS				
TOTAL	81.3	1960		
24 HR TOTAL	25.0	02/11-02/12/1983		
2010...				
TOTALS	44.0		36.9	7.1
LIQUID EQUIV	4.40		3.70	0.70
SINCE 7/1	0.8		7.7	-6.9
LIQUID 7/1	0.08			
DAYS >= TRACE	33		18.4	14.6
DAYS >= 1.0	7		12.8	-5.8
GREATEST				
SNOW DEPTH	22	02/11		
24 HR TOTAL	12.3	02/10		

DEGREE_DAYS

HEATING TOTAL	4894	5347	-453
SINCE 7/1	1951	1949	2
COOLING TOTAL	1421	962	459
SINCE 1/1	1421	955	466

FREEZE DATES

RECORD	
EARLIEST	09/24/1963
LATEST	05/11/1966
2010...	
EARLIEST	11/02
LATEST	03/26

....

WIND (MPH)

AVERAGE WIND SPEED	7.0		
HIGHEST WIND SPEED/DIRECTION	41/270	DATE	04/16
HIGHEST GUST SPEED/DIRECTION	63/250	DATE	04/16

SKY COVER

POSSIBLE SUNSHINE (PERCENT) MM

NUMBER OF DAYS FAIR	88
NUMBER OF DAYS PC	139
NUMBER OF DAYS CLOUDY	120

AVERAGE RH (PERCENT) 64

WEATHER CONDITIONS. NUMBER OF DAYS WITH

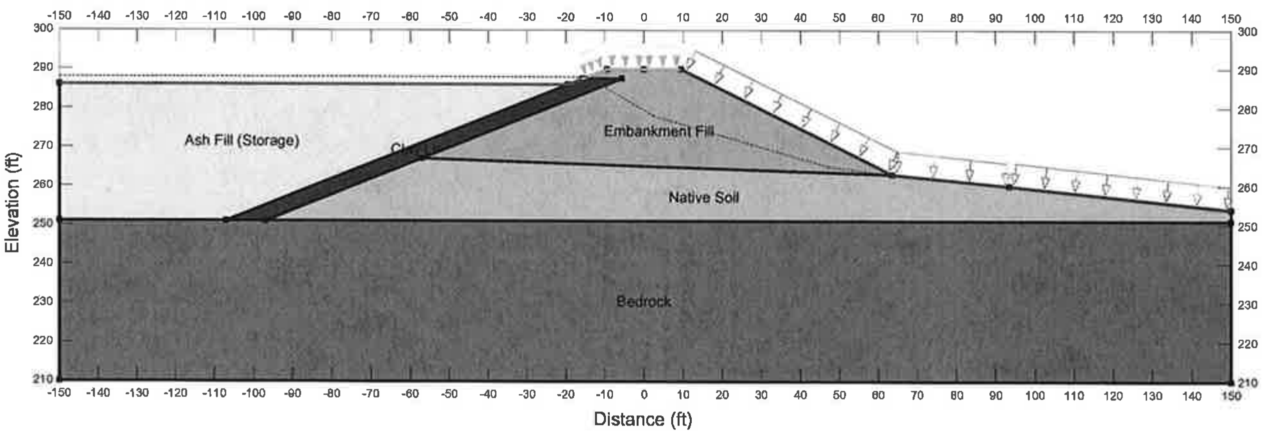
THUNDERSTORM	30	MIXED PRECIP	0
HEAVY RAIN	40	RAIN	61
LIGHT RAIN	118	FREEZING RAIN	0
LT FREEZING RAIN	2	HAIL	0
HEAVY SNOW	4	SNOW	6
LIGHT SNOW	31	SLEET	2
FOG	152	FOG W/VIS <= 1/4 MILE	12
HAZE	135		

\- INDICATES NEGATIVE NUMBERS.
R INDICATES RECORD WAS SET OR TIED.
MM INDICATES DATA IS MISSING.
T INDICATES TRACE AMOUNT.

LA CORTE

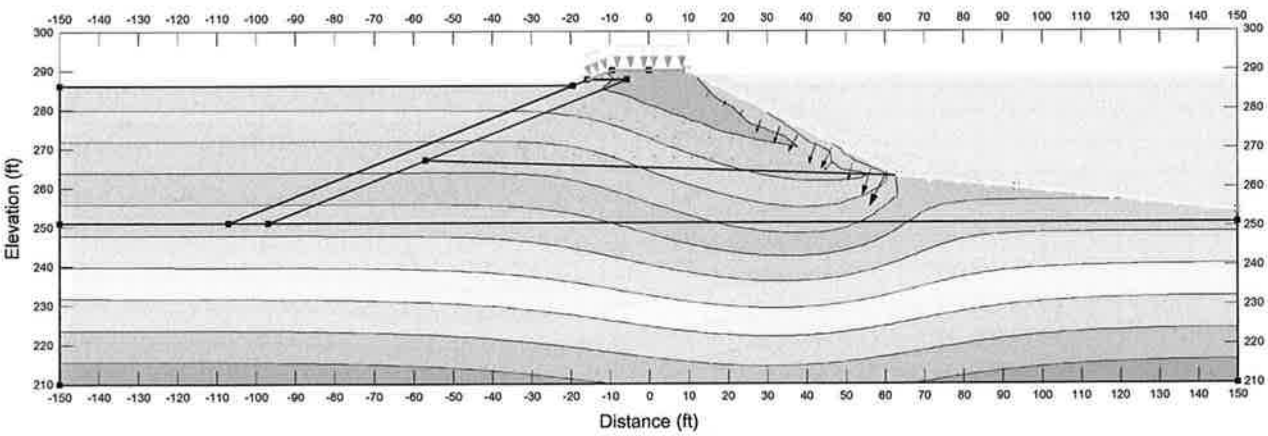
APPENDIX D

SEEPAGE ANALYSIS PLATES



Material Input Properties
Name: Bedrock Model: Saturated Only K-Sat: 1e-010 ft/sec Volumetric Water Content: 0 ft³/ft³ Mv: 0 /psf K-Ratio: 1 K-Direction: 0 °
Name: Native Soil Model: Saturated Only K-Sat: 1e-008 ft/sec Volumetric Water Content: 0 ft³/ft³ Mv: 0 /psf K-Ratio: 1 K-Direction: 0 °
Name: Clay Liner Model: Saturated Only K-Sat: 1e-009 ft/sec Volumetric Water Content: 0 ft³/ft³ Mv: 0 /psf K-Ratio: 1 K-Direction: 0 °
Name: Ash Fill (Storage) Model: Saturated Only K-Sat: 1e-008 ft/sec Volumetric Water Content: 0 ft³/ft³ Mv: 0 /psf K-Ratio: 1 K-Direction: 0 °
Name: Embankment Fill Model: Saturated / Unsaturated K-Function: Embankment Fill Unsat K Vol. WC. Function: Embankment Fill - Vol. WC K-Ratio: 1 K-Direction: 0 °

Transient Seepage
Brunner Island Ash Basin No. 6
Station 21+80 (Section 1-1)
Manchester Township, Pennsylvania



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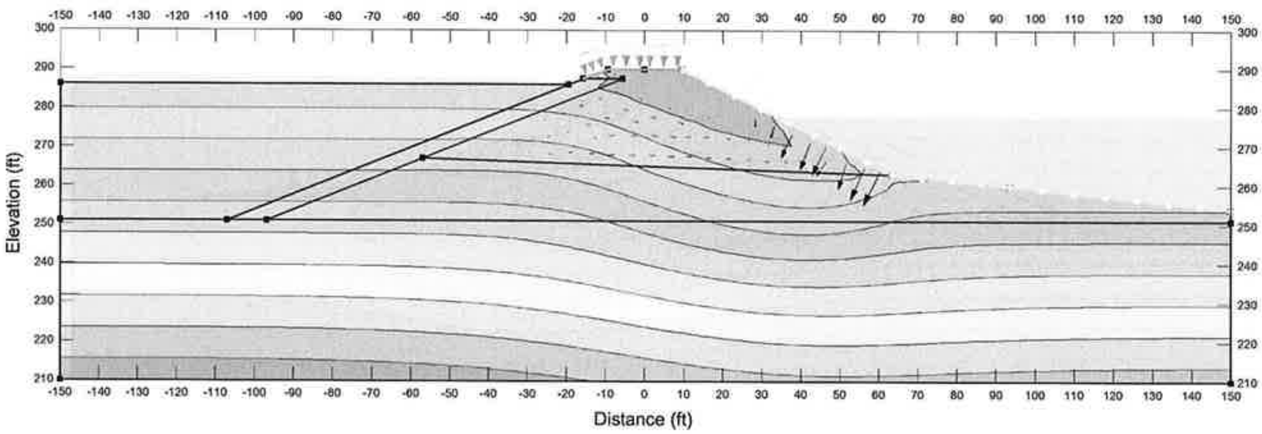
Brunner Island Ash Basin No. 6
Station 21+80 (Section 1-1)
Manchester Township, Pennsylvania



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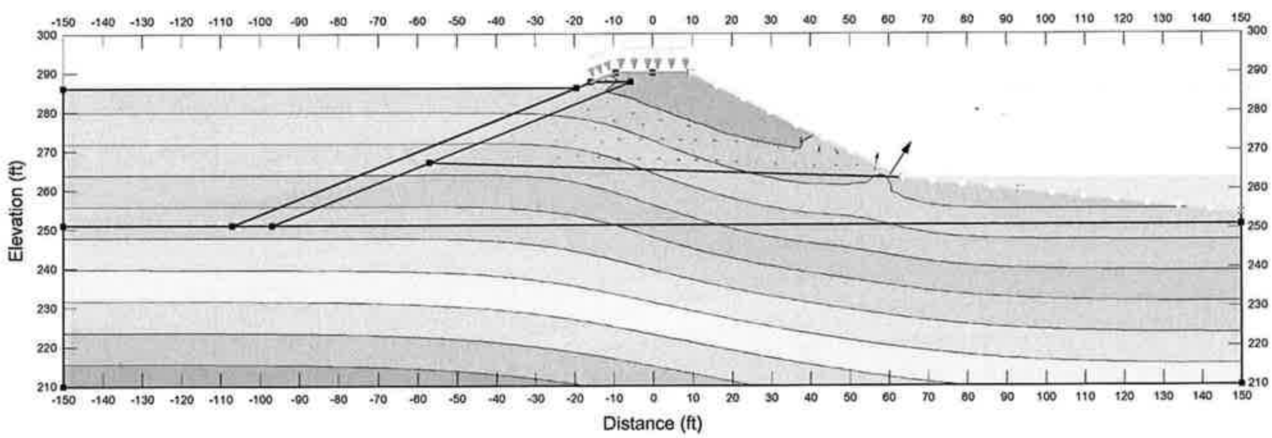
Name: Embankment Fill Model: Saturated / Unsaturated K-Function: Embankment Fill Unsat K Vol. WC. Function: Embankment Fill - Vol. WC K-Ratio: 1 K-Direction: 0 °

Transient Seepage (5)
Brunner Island Ash Basin No. 6
Station 21+80 (Section 1-1)
Manchester Township, Pennsylvania



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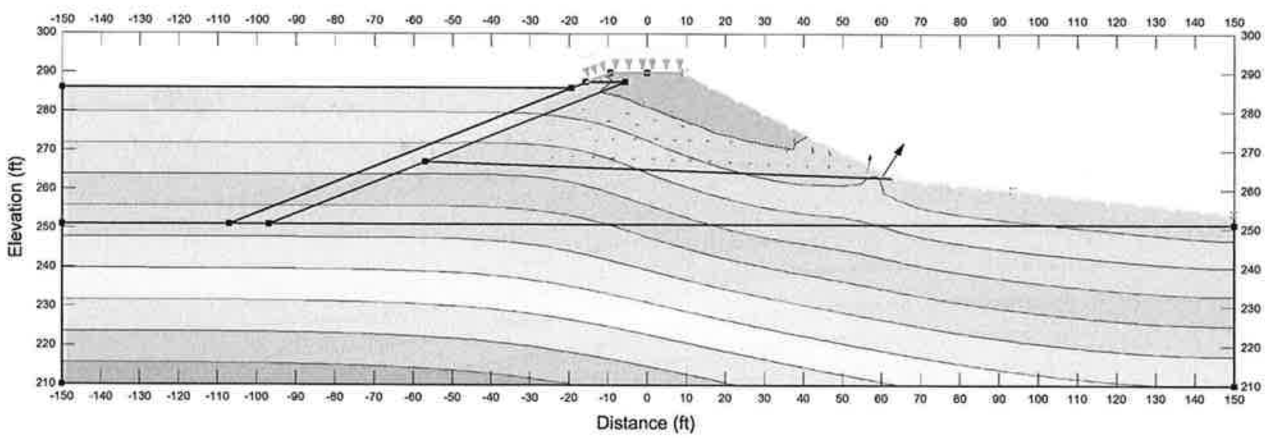
Transient Seepage (5)
Brunner Island Ash Basin No. 6
Station 21+80 (Section 1-1)
Manchester Township, Pennsylvania



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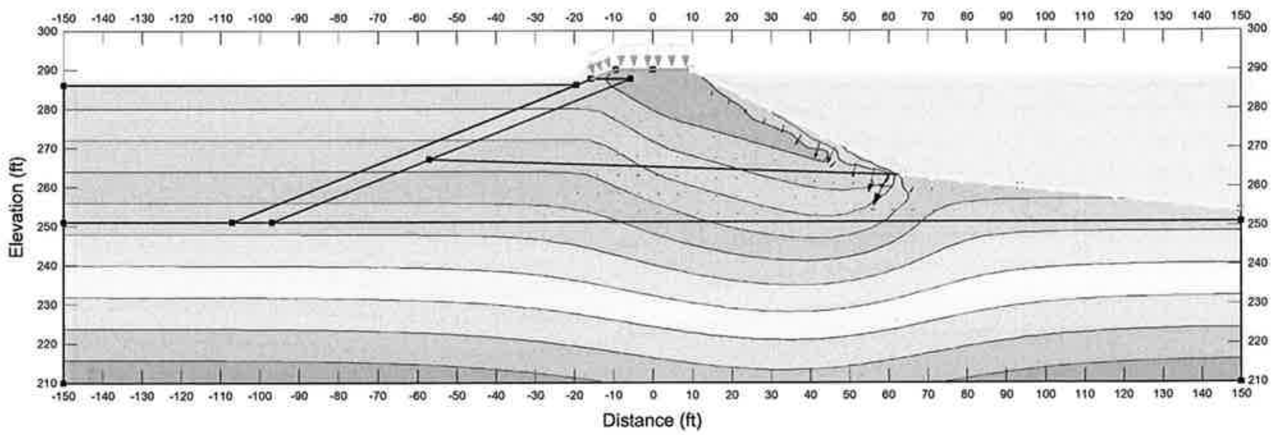
Name: Embankment Fill   Model: Saturated / Unsaturated   K-Function: Embankment Fill Unsat K   Vol. WC. Function: Embankment Fill - Vol. WC   K-Ratio: 1   K-Direction: 0 °

Transient Seepage (5)
Brunner Island Ash Basin No. 6
Station 21+80 (Section 1-1)
Manchester Township, Pennsylvania



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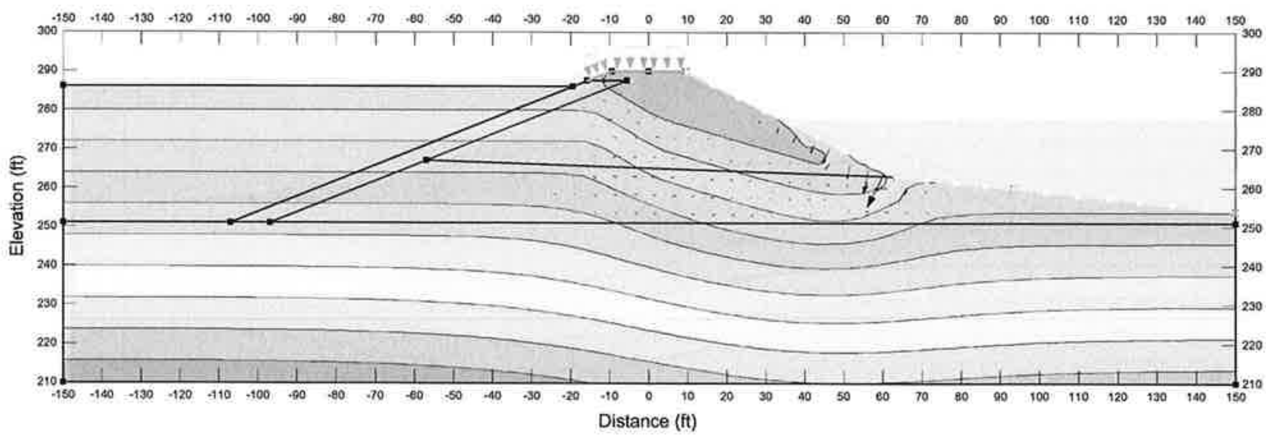
Transient Seepage (4)
Brunner Island Ash Basin No. 6
Station 21+80 (Section 1-1)
Manchester Township, Pennsylvania



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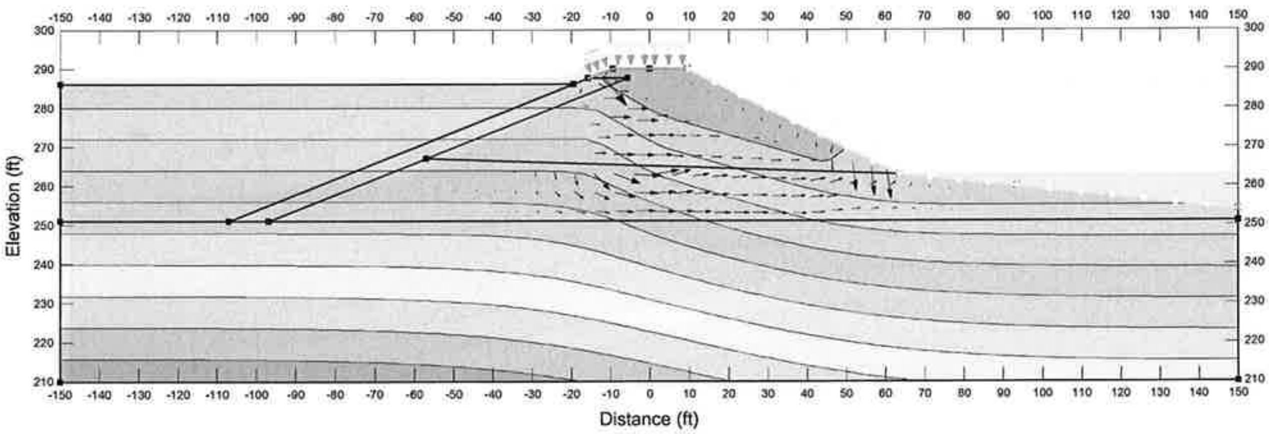
Transient Seepage (5)
Brunner Island Ash Basin No. 6
Station 21+80 (Section 1-1)
Manchester Township, Pennsylvania



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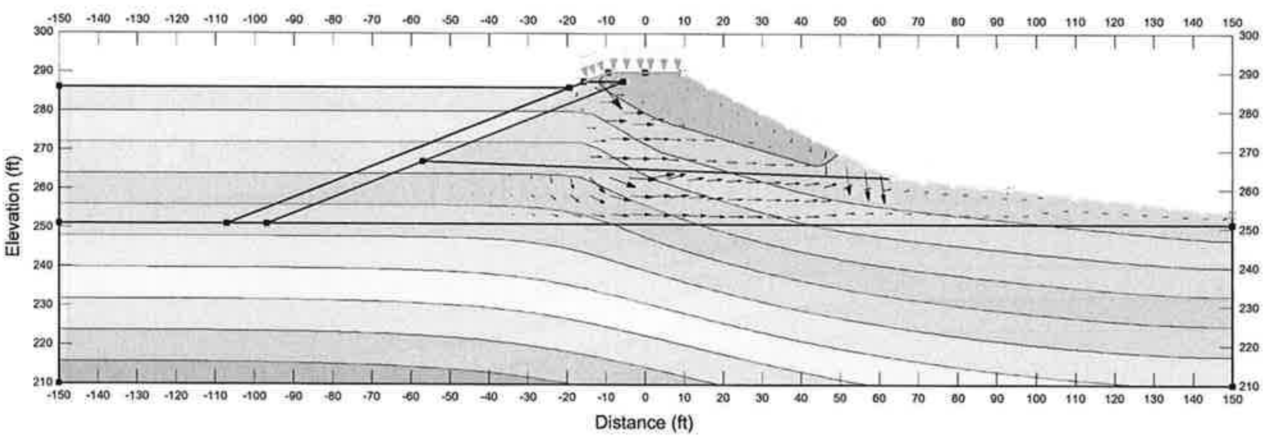
Transient Seepage (5)
Brunner Island Ash Basin No. 6
Station 21+80 (Section 1-1)
Manchester Township, Pennsylvania



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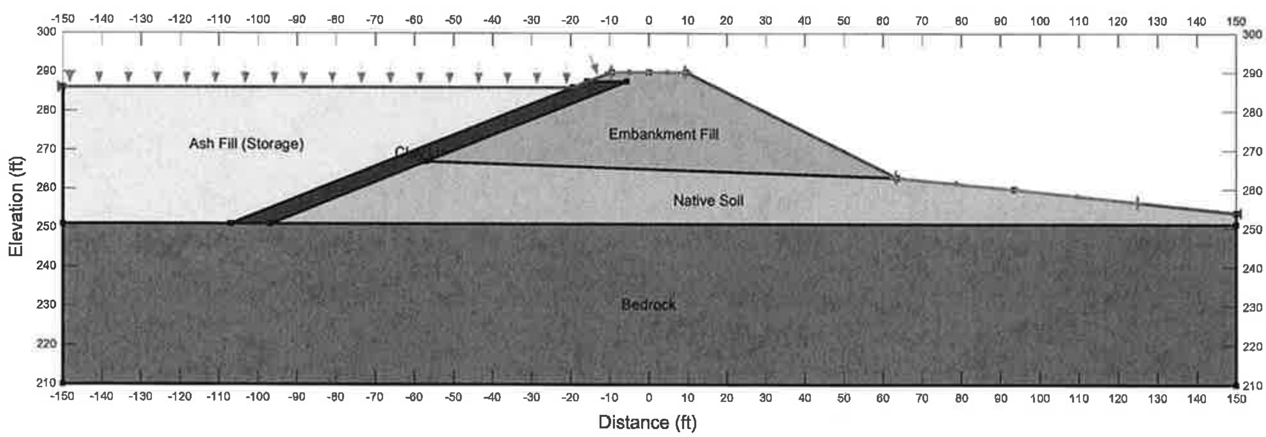
Transient Seepage (5)
Brunner Island Ash Basin No. 6
Station 21+80 (Section 1-1)
Manchester Township, Pennsylvania

APPENDIX E

SLOPE STABILITY ANALYSIS PLATES



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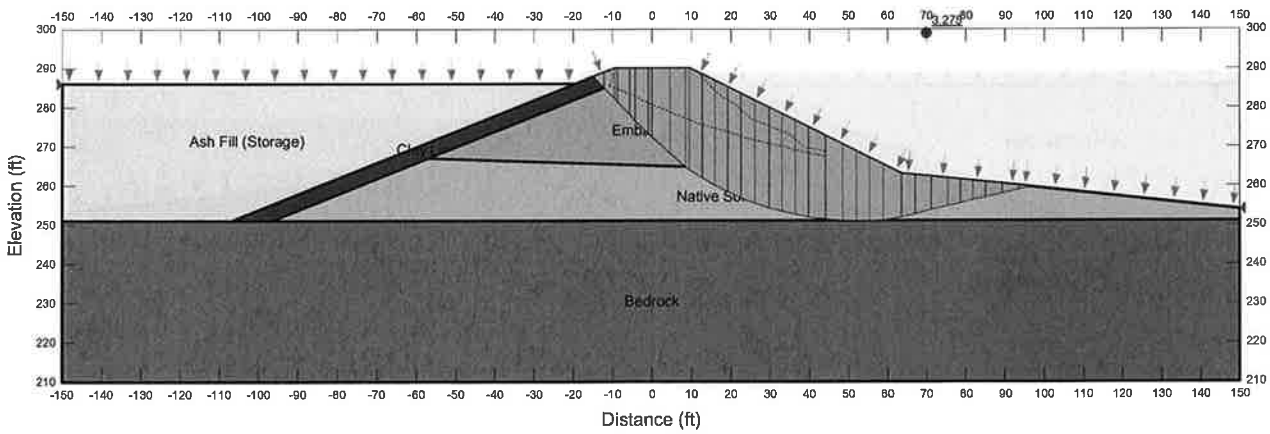
Name: Ash Fill (Storage) Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion: 0 psf Phi: 30 °
Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Unit Wt. Above Water Table: 125 pcf Cohesion: 0 psf Phi: 37 °

Slope Stability (6)
Brunner Island Ash Basin No. 6
Station 21+80 (Section 1-1)
Manchester Township, Pennsylvania



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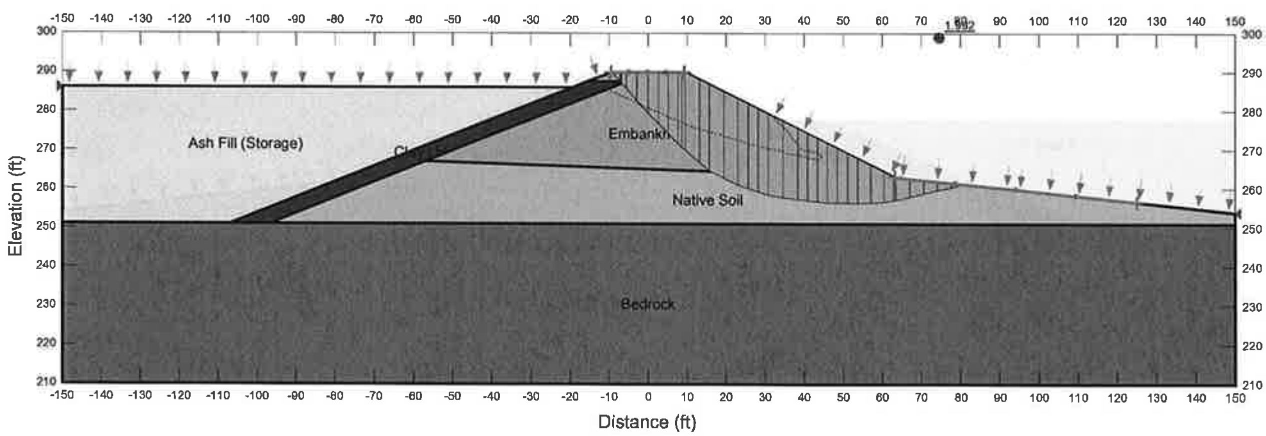
Brunner Island Ash Basin No. 6
Station 21+80 (Section 1-1)
Manchester Township, Pennsylvania



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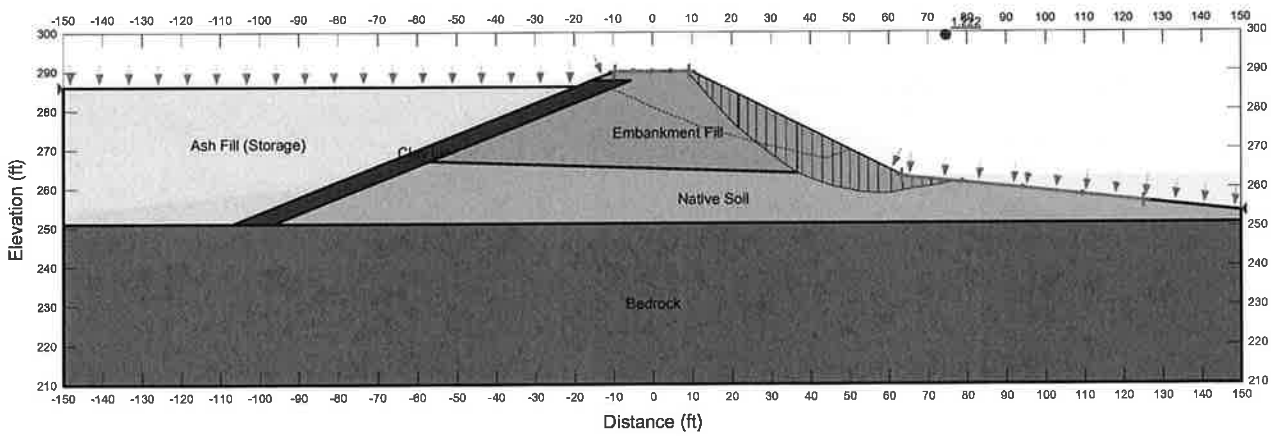
Slope Stability (6)
Brunner Island Ash Basin No. 6
Station 21+80 (Section 1-1)
Manchester Township, Pennsylvania



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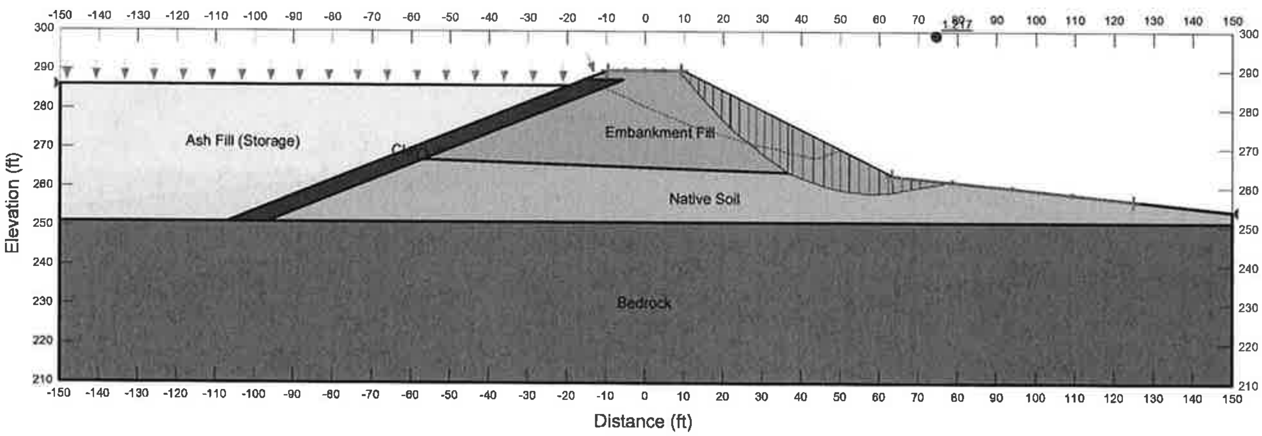
Slope Stability (6)
Brunner Island Ash Basin No. 6
Station 21+80 (Section 1-1)
Manchester Township, Pennsylvania



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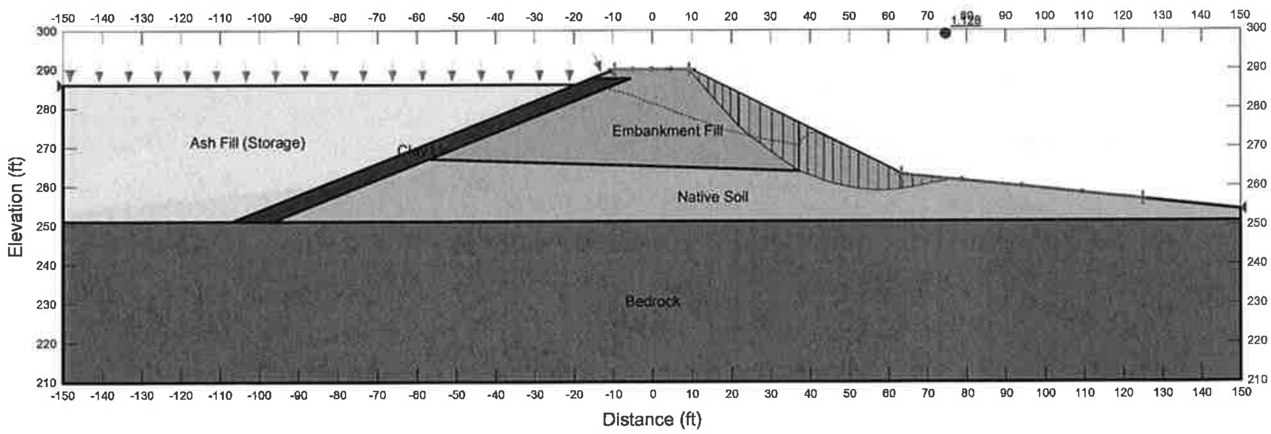
Slope Stability (6)
Brunner Island Ash Basin No. 6
Station 21+80 (Section 1-1)
Manchester Township, Pennsylvania



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Slope Stability (6)
Brunner Island Ash Basin No. 6
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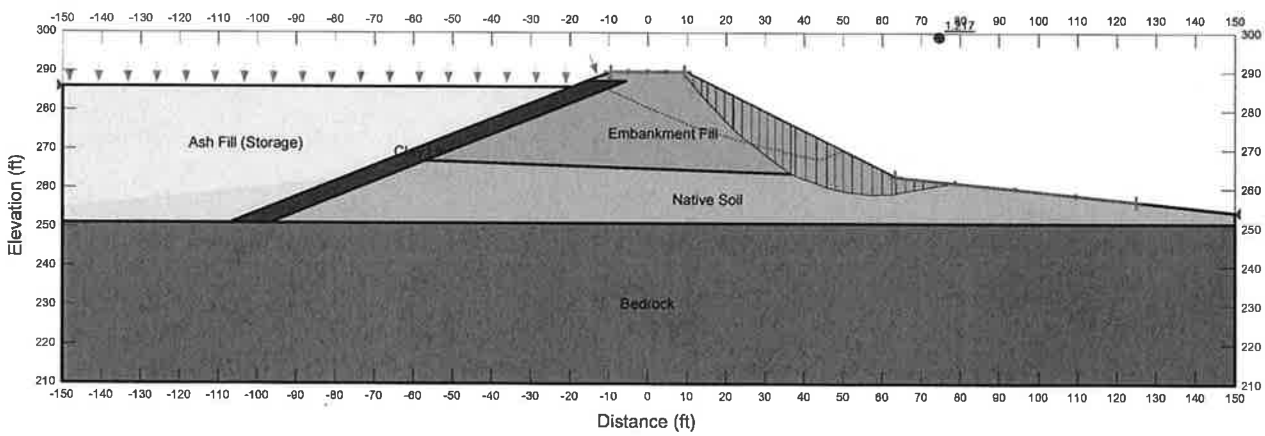
Manchester Township, Pennsylvania



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Slope Stability (6)
Brunner Island Ash Basin No. 6
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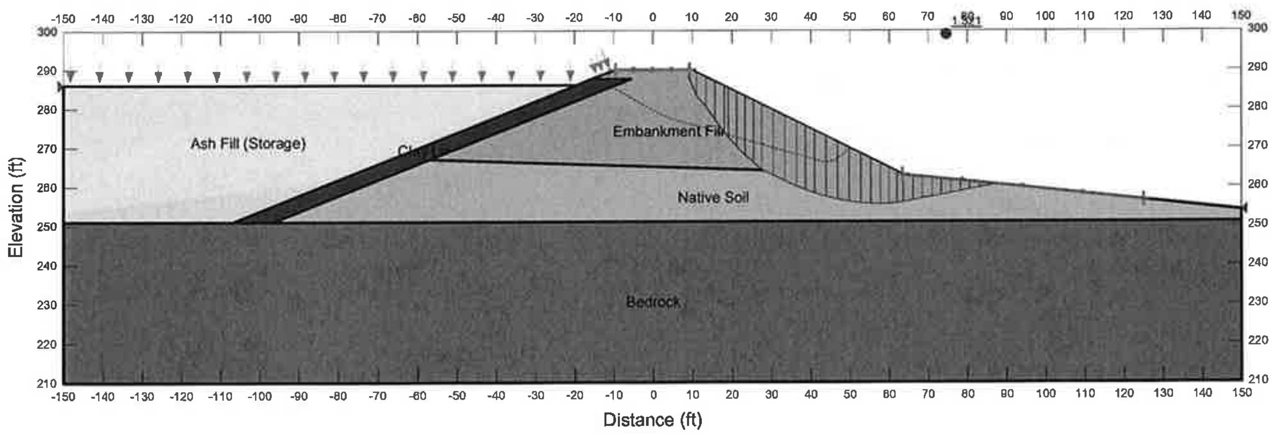

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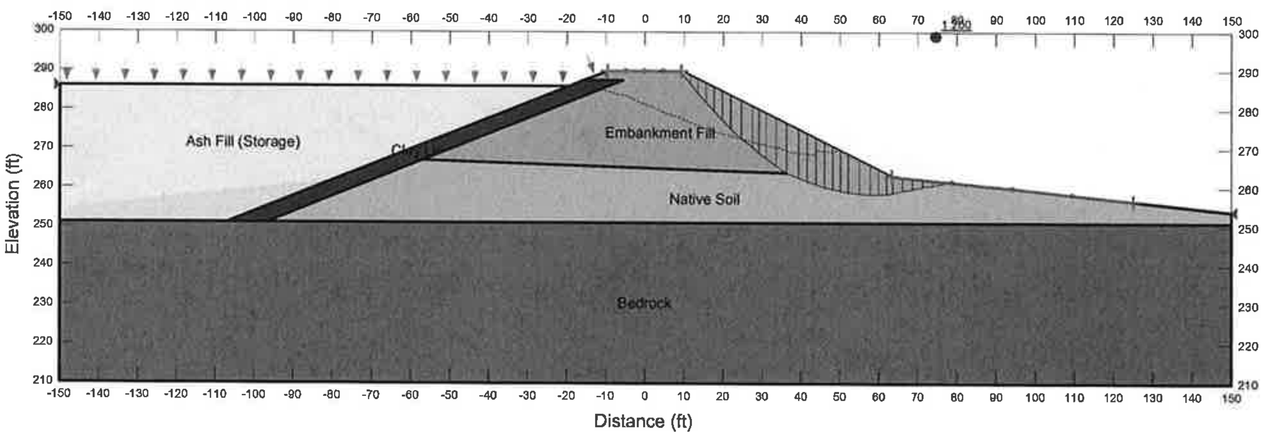

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Slope Stability (6)
Brunner Island Ash Basin No. 6
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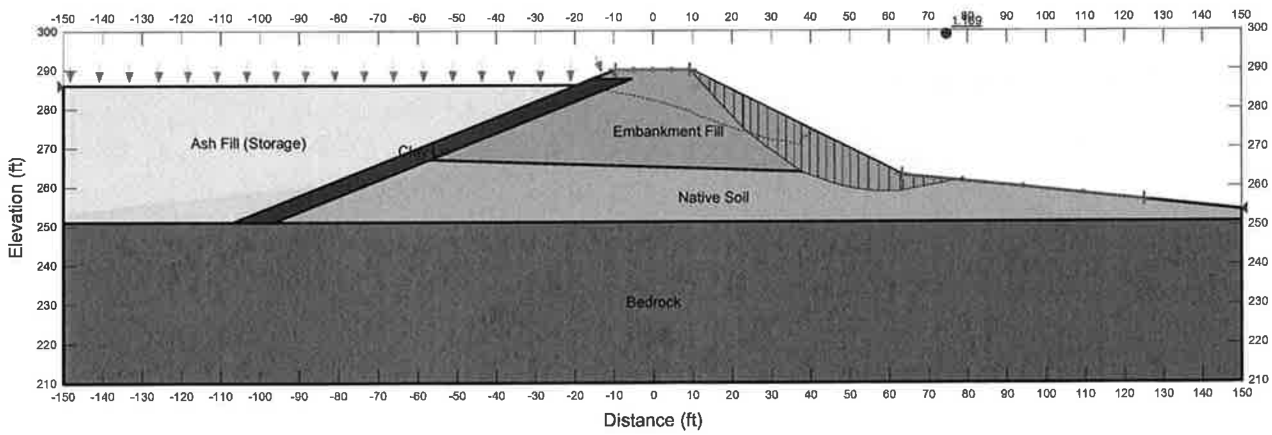
Manchester Township, Pennsylvania



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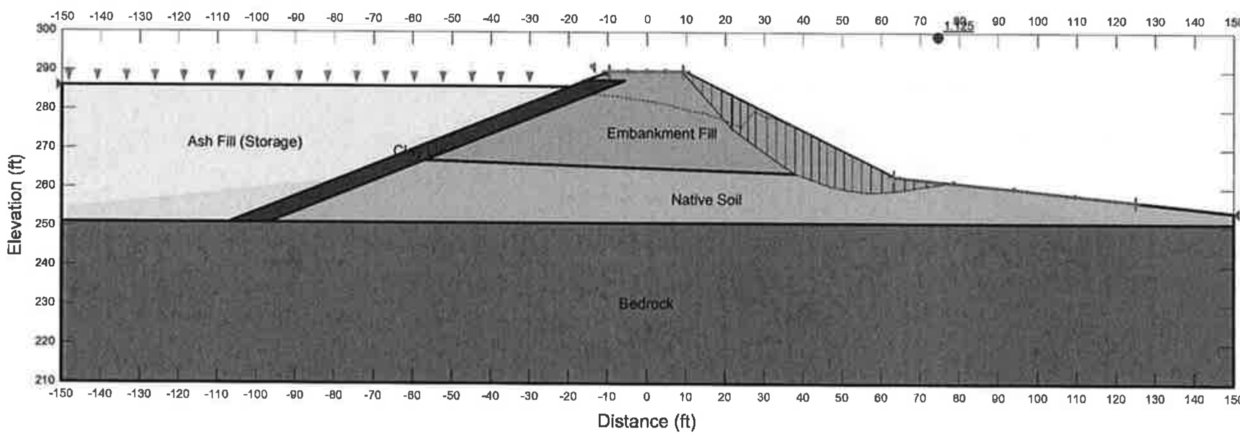
Slope Stability (6)
Brunner Island Ash Basin No. 6
Station 21+80 (Section 1-1)
Manchester Township, Pennsylvania



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Slope Stability (6)
Brunner Island Ash Basin No. 6
Station 21+80 (Section 1-1)
Manchester Township, Pennsylvania

September 7, 2012 390/181182

Mr. Benjamin Wilburn, E.I.T.
Support Engineer
Generation Technical Services
PPL Generation, LLC
Two North Ninth Street (GENPL6)
Allentown, PA 18101-1179

Subject: **Spillway Design Flood Analysis**
Brunner Island Ash Basin No. 6

Dear Mr. Wilburn:

This letter report presents the findings of the Spillway Design Flood Analysis of Brunner Island Ash Basin No. 6.

1.0 Executive Summary

PPL is in the process of decommissioning Ash Basin No. 6 at their Brunner Island Steam Electric Station. The United States Environmental Protection Agency (USEPA) is currently evaluating Ash Basin No. 6, and has requested that PPL provide detailed hydrologic and hydraulic analyses to verify that the ash basin can safely pass the Spillway Design Flood (SDF). The Pennsylvania Department of Environmental Protection (PADEP) has classified the ash basin as B-3, corresponding to a medium-sized, significant-hazard-potential dam. The SDF for a Class B-3 dam is ½ of the Probable Maximum Flood (PMF).

The ash basin consists of a main basin with a polishing pond on the southern end. The ash basin has a total area of 76.4 acres and is surrounded by a perimeter dike with a nominal crest elevation of 290 feet. The northern end of the main basin has been filled with ash to near the crest of the dike, and has a surface area of 55.3 acres. The area of the open pool at the southern end of the main basin is 12.3 acres, which is controlled by a stoplog weir in the outlet structure. The top-of-stoplog elevation is 285.75 feet, providing a normal water surface elevation of approximately 286.0 feet and a normal freeboard of 4.0 feet. The main basin is separated from the polishing pond by an intermediate dike, with the main basin outlet structure connecting the two basins with a 48-inch-diameter buried pipe. The polishing pond is used for final treatment of the ash basin water before it is discharged to the Susquehanna River. The polishing pond is controlled by twin baffled morning glory outlet structures, with top-of-weir elevations of 268.0 feet, which both discharge into a single 48-inch-diameter pipe to the river. The water elevation in the polishing pond is normally maintained at slightly above elevation 268.0 feet.

The ash basin is somewhat unique from a hydrological perspective, in that the ash basin is elevated with respect to the surrounding ground and is totally self contained, with no tributary inflow from outside of the basin. Flow out of the basin could occur for portions of the filled section of the basin, although this study conservatively assumed that all rainfall is routed through the basin. A rainfall/storage/discharge model has been created to model the hydrologic response of the ash basin to a storm corresponding to the ½ PMF, per PADEP regulations. The Probable Maximum Precipitation (PMP) has been taken from the previous analysis of a nearby ash basin, Holtwood Ash Basin No. 2, which is comparable in size and is located about 25 miles away. The full 24-hour PMP, with a precipitation value of 37 inches, was utilized in the hydraulic model, resulting in a peak PMP total inflow volume of 217.9 acre-feet to the main basin. A precipitation value of 19.22 inches was then solved iteratively to estimate the ½ PMF. Due to the small size of the basin and limited infiltration, the precipitation of 19.22 inches that results in the ½ PMF is very close to the ½ PMP value of 18.5 inches.

The discharge from the polishing pond will be affected by backwater effects of the Susquehanna River. Because the size and hydrologic timing of the drainage areas for the ash basin and the Susquehanna River differ greatly, a 100-year flood was assumed to be occurring concurrently on the Susquehanna River, which results in a peak stage of 278.2 feet adjacent to the ash basin.

The peak stage within the main basin resulting from the ½ PMF was determined to be elevation 288.42 feet, occurring 4.83 hours into the storm. A wave run-up of 0.98 feet for flood conditions and 1.46 feet for normal conditions was estimated, assuming a 62 mile-per-hour, one-minute duration wind speed in accordance with Bureau of Reclamation recommendations. This results in a net freeboard of between 0.6 feet and 0.12 feet during the ½ PMF, which is considered acceptable.

2.0 Project Description and History

Ash Basin No. 6 is located between Black Gut Creek and the Susquehanna River at the southern end of Brunner Island in East Manchester Township, York County. The island is located along the western shore of the river and can be located on the York Haven USGS 7.5 Minute Quadrangle Map at 40°04′59″N, 76°40′58″W. An aerial view and drawings of Ash Basin No. 6 are provided in Appendix A.

The ash basin consists of a main basin with a polishing pond on the southern end. The ash basin has a total area of 76.4 acres and is surrounded by a perimeter dike with a nominal crest elevation of 290 feet. The northern end of the main basin has been filled with ash to near the crest of the dike, and has a surface area of 55.3 acres. The area of the open pool at the southern end of the main basin is 12.3 acres, which is controlled by a stoplog weir in the outlet structure. The top-of-stoplog elevation is 285.75 feet, providing a normal water surface elevation of approximately 286.0 feet and a normal freeboard of 4.0 feet. The main basin is separated from the polishing pond by an intermediate dike, with the main basin outlet structure connecting the two basins with a 48-inch-diameter buried pipe. The polishing pond is used for final treatment of the ash basin water before it is discharged to the Susquehanna River. The polishing pond has an area of 2.7 acres and is controlled by twin baffled morning glory outlet structures, with top-of-weir elevations of 268.0 feet, which both discharge into a single 48-inch-diameter pipe to the river. The water elevation in the polishing pond is normally maintained at slightly above elevation 268.0 feet.

The perimeter dike is constructed with random earth fill and includes a 10-foot-thick clay liner covering the upstream slope from bedrock to elevation 287.5 feet. The crest of the perimeter dike is nominally at elevation 290 feet, and the maximum height of the dike is about 30 feet. Overall, the perimeter dike is about 8,300 feet long.

The polishing pond outlet structure consists of two, 60-inch-diameter, reinforced concrete riser pipes with a top-of-weir elevation of 268.0 feet, draining into a single, 48-inch-diameter, reinforced concrete discharge pipe that discharges into the Susquehanna River. A flap gate is provided at the river end of the discharge pipe to prevent river water from entering the ash basin during high tailwater conditions. The riser pipes were previously equipped with upstream emergency flap gates as an additional means to stop discharge to the river; however, the gates were determined to be vulnerable to unintended closure and are now welded in the open position providing approximately half the open area of the 60-inch-diameter riser.

The PADEP has regulatory jurisdiction for the project and has classified the ash basin as B-3, corresponding to a medium-sized, significant-hazard-potential dam. The SDF for a Class B-3 dam is ½ of the PMF. The USEPA has recently become involved with the assessment of ash basins and is currently evaluating Ash Basin No. 6. In their email dated August 30, 2012, the USEPA stated that PPL did not yet provide them with detailed hydrologic and hydraulic analyses necessary to verify that the ash basin can safely pass the SDF, and they presented suggestions regarding how these analyses should be conducted. PPL is currently in the process of decommissioning Ash Basin No. 6, but must comply with applicable regulations prior to and following closure.

3.0 Hydrologic and Hydraulic Analyses

The hydrologic and hydraulic analyses consisted of the following steps:

- Development of the PMP and determination of the PMF inflows;
- Scaling the precipitation to result in an inflow of ½ PMF flows for the SDF;
- Routing of the SDF through the filled part of the basin and into the open basin;
- Discharge of flow from the main basin to the polishing pond;
- Routing of the tributary inflow to the polishing pond and the inflow from the main basin; and
- Discharge from the polishing pond into the Susquehanna River.

Hydrologic Model

The hydrologic model, HydroCAD v9.0 (model), was selected for use due to the small size of the study basin and the programs' ability to model complex outlet controls. HydroCAD combines portions of the NRCS computer programs TR-20, TR-55, and SBUH, in addition to built-in hydraulics, graphics, database references, and on-screen routing diagrams. The program models the precipitation, runoff, and routing of flows through the drainage, as well as the outlet hydraulics of the structures.

Development of the Spillway Design Flood

PADEP calls for the SDF to be ½ of the PMF. USEPA requested development of the PMP using National Weather Surface (NWS) Hydrometeorological Records HMR 51 and 52. PPL recently completed a hydrologic and hydraulic analysis at another ash basin, Holtwood Ash Basin No. 2, which included development of the PMP. Holtwood Ash Basin No. 2 is nearby, located 25 miles to the south along the Susquehanna River, has a similar drainage area (120 acres at Holtwood, versus 76.4 acres at Brunner Island), and is located at the same relative elevation, (592 feet at Holtwood versus 290 feet at Brunner Island). Given the similar elevations and locations within the Susquehanna Valley for the Holtwood and Brunner site, the full PMP from the Holtwood study of 37 inches of precipitation over 24 hours was assumed for the Brunner Island site.

The Holtwood PMP rainfall distribution was entered into HydroCAD and executed to estimate the full PMF volume into the main basin for Brunner Island. The peak rainfall was then solved by an iterative process to determine the precipitation required to result in one half the PMF inflow volume. This was determined to be 19.22 inches of precipitation over 24 hours, using the same unit temporal distribution as the Holtwood PMP. Therefore, 51.9 percent of the PMP was found to produce a ½ PMF and was used for the SDF.

Routing of the SDF

HDR used HydroCAD to model the hydrologic response of the basin to the SDF. The HydroCAD model is capable of simulating the rainfall, runoff, and routing, and provides a detailed simulation of the outlet hydraulics for the complicated arrangement of stoplog weirs, vertical inlets, and piping. The HydroCAD method uses NRCS curve number and time-of-concentration techniques with reach routing to calculate discharge hydrographs. The model uses the dynamic Muskingum-Cunge routing for reach routing, as apposed to the Modified Puls method as suggested by the USEPA. Considering the very short routing reaches and the compact basin under study, the differences in routing are inconsequential.

Infiltration was assumed in the above-water part of the basin, utilizing Curve Numbers of 80 and 88, corresponding to a moderately impermeable soil cover, per TR-55 methodology. Of the 128.9 acre-feet of precipitation that falls during the modeled storm, the total infiltration into the above-water part of the basin was 7.7 acre-feet, or an average of 1.2 inches of rainfall over the 76.4 acres of the basin. PPL maintains several piezometers within the above-water part of the basin. The depth to the ground water table and the anticipated void space provide adequate subsurface storage capacity so that the limited infiltration assumed can be accommodated without saturation.

Discharge from the Main Basin, Polishing Pond, and Into the Susquehanna River

The discharge structure from the main basin consists of a stoplog-controlled concrete vault that discharges through a 48-inch-diameter reinforced concrete pipe (RCP) into the polishing pond. The primary control during normal operating conditions is stoplogs which extend from the outlet invert to elevation 285.75 feet, and all flow must overflow the stoplogs. Secondary means of conduit closure are available, including a skimmer gate section which could form an emergency stoplog slot as well as a gate, located immediately upstream of the pipe inlet. These secondary means of closure were assumed to be open and were assumed to have negligible headloss. The structure geometry was taken from construction drawings for the outlet provided by PPL. A Manning's n value of 0.015 was assumed, corresponding to concrete pipe formed with rough forms. HydroCAD was used to solve the discharge dynamically for the inflow and outflow hydrographs, accounting for the effects of varying water levels in the main basin, polishing pond, and the Susquehanna River. The current top-of-stoplog elevation of 285.75 feet was provided by PPL, and the starting reservoir elevation of 286.0 was based on observations made by HDR during a site visit in June 2012. Discharge was controlled by the stoplogs for the range of main basin and polishing pond elevations encountered in this study; the 48-inch-diameter RCP downstream piping did not limit discharge.

The polishing pond outlet structure consists of two vertical 60-inch-diameter risers that merge with one 48-inch-diameter discharge pipe that passes through the perimeter dike, enters and exits an emergency closure structure, and discharges to the river where a heavy flap valve serves as a back-flow preventer. The top-of-weir elevation is 268.0 feet, controlling the polishing pond elevations. The polishing pond outlet currently has several flow obstructions, including a skimmer weir, a grating deck, emergency flap gates atop the control structures, and the downstream flap valve. Precisely modeling these obstructions would be cumbersome due to the non-standard shapes and complex head losses; therefore, a conservative estimate of available capacity was made. The main inlet control for the vertical risers is the emergency flap gates, which cover the opening of the risers with a hinge running along the centerline of the opening, resulting in half the area of the 60-inch-diameter when fully open. The flap gates have been welded in the fully open position, providing a "half moon" shaped opening of approximately 9.8 square feet. A conservative estimate of unrestricted 30-inch-diameter opening risers, or 4.9 square feet, was modeled to account for the multiple restrictions. A Manning's n value of 0.015 was assumed for the 48-inch-diameter outlet pipe, corresponding to concrete pipe formed with rough forms.

Because the size and hydrologic timing of flows from the drainage areas for the ash basin and the Susquehanna River basin differ greatly, a 100-year flood was assumed to be occurring concurrently on the Susquehanna River with the ½ PMF of the ash basin, resulting in a peak river stage of 278.2 feet at the outlet from the polishing pond. This elevation was taken from the Slope Stability Assessment Report by HDR, dated December, 2009. The Susquehanna River flows react relatively slowly to basin precipitation compared to the ash basin, and the river flood level was assumed constant at the 100-year flood level for the duration of the ash basin flood assessment.

Analysis Results

TABLE 1
SPILLWAY DESIGN FLOOD ANALYSIS SUMMARY –
STARTING ELEVATION 286.0 FEET

Main Basin	
Peak Stage, feet	288.4
Peak Discharge, cfs	112.9
Time to Peak Stage, hours	4.8
Time to Peak Discharge, hours	4.9
Polishing Pond	
Peak Stage, feet	285.6
Peak Discharge, cfs	101
Time to Peak, hours	6.8

The peak stage within the main basin resulting from the ½ PMF was determined to be elevation 288.4 feet, occurring 4.8 hours into the storm. A wave run-up of 1.0 feet for flood conditions and 1.5 feet for normal conditions was estimated, assuming a 62-mile-per-hour, one-minute-duration wind speed in accordance with Bureau of Reclamation recommendations. This results in a net freeboard of between 0.1 feet and 0.6 feet during the ½ PMF, which is considered acceptable. The HydroCAD analysis report and wave run up calculation are provided in Appendix B.

4.0 Conclusions and Recommendations

The SDF can safely be passed if the starting main basin pool elevation is at or below 286.00 feet. The following recommendations should be considered.

1. Verify the nominal top-of-dike elevation of 290.0 feet assumed in the analysis.
2. Control vegetation along the interior of the main basin and polishing pond to minimize the potential for trash build up.
3. Staff the site during extreme floods so that discharge structure performance can be monitored and appropriate actions can be taken, if necessary.

4. Remove or modify flow restrictions from the polishing pond outlet structure, including the flap valves and grating. Specific recommendations can be made after further analyses.

5. Verify that field conditions are consistent with the assumptions of minimal headloss in the discharge pipelines, control structures, and regulating or control valves and gates. Perform additional analyses or modify the structures if necessary.

6. Take appropriate measures to restore the reservoir to normal levels after floods to reduce the potential adverse effects of back-to-back storms.

7. Account for spillway discharge requirements in long-term closure plans, including the need to prevent or safely pass trash and vegetation, and assess long-term maintenance requirements.

HDR appreciates the opportunity to perform this work for PPL. If you have any questions or comments, please contact us.

Sincerely,

HDR ENGINEERING, INC.

Christopher R. MacDonald, P.E.
Civil Engineer

Adam N. Jones, P.E.
Senior Engineer

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
ADAM JONES
ENGINEER
No.PE075739

9/7/12

Appendix A: Reference Photos and Drawings
Appendix B: HydroCad Analysis Report

APPENDIX A

REFERENCE PHOTOS AND DRAWINGS

THIS DRAWING IS THE PROPERTY OF PPL CORP. AND CONTAINS PROPRIETARY AND CONFIDENTIAL INFORMATION WHICH MUST NOT BE DUPLICATED, USED OR DISCLOSED WITHOUT WRITTEN AUTHORIZATION FROM PPL CORP.

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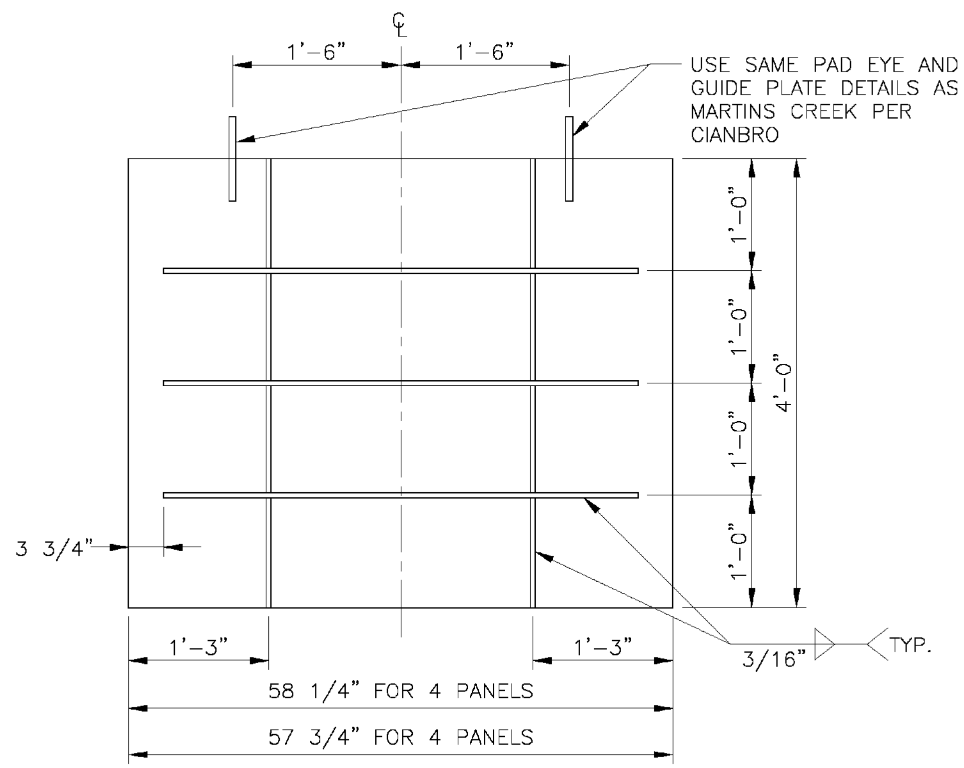
Fax: (207) 487-3124
www.KleinschmidtUSA.com

Page:	BI-SK-1
Project No:	112-054
By: LLC	Date: 1/10/06
Checked: JML	Date: 1/13/06

Project: BRUNNER ISLAND FOR CIANBRO BALTIMORE

Subject: ASH BASIN OUTLET MODIFICATIONS

SKIMMER GATE PANELS



PANEL ELEVATION

3/8"= 1'-0"

NOTES:

1. PLATE 1/2" THICK
2. STIFFENERS 1/2"x 4"
3. MATERIAL – STAINLESS STEEL WITH MIN. Fy=30 ksi
4. TOTAL 8 PANELS
5. DESIGN WATER ELEVATION EL. 290'
6. IN LIEU OF STAINLESS STEEL, GRADE 50 CARBON STEEL CAN BE USED WITH THE FOLLOWING TREATMENT:

   SHERWIN WILLIAMS TARGUARD COAL TAR EPOXY, 10 TO 16 MILS DFT, SURFACE PREP SSPC-SP6, OR APPROVED EQUAL

J:\112\054\Drawings\112-054 Brunner Revised 1-10-06.dwg

NO.	DATE	ACCT.	REVISION	BY	REVIEWED	APPROVED

ACCT-
SCALE- NTS
BY- KLEINSCHMIDT
REVIEWED G.D.HOPFER

BRUNNER ISLAND S.E.S.
ASH BASIN OUTLET MODIFICATIONS
SKIMMER GATE PANEL
ELEVATION AND DETAILS

APPROVED KLEINSCHMIDT 1/13/06 DATE

PPL CORP.

ppl

PPL DRAWING NO. B324374 | SHEET NO. 1 | REV. 0

MF

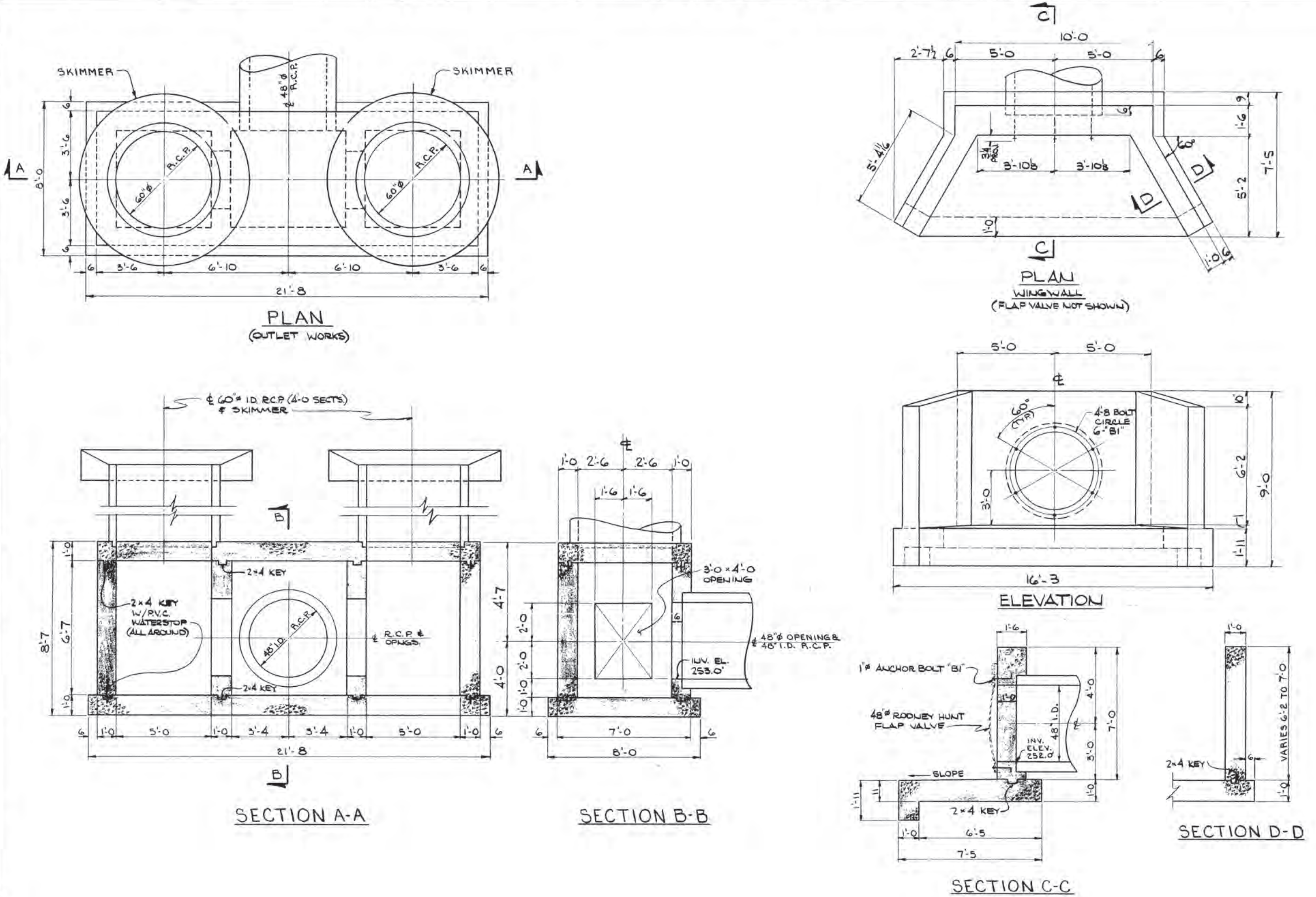
PC CAD

PPL CORP. FORM 4163B (4/00)
Nov. 6, 2006 - 8:19 AM

FRACTIONAL DECIMAL

LOCATION CODES SORTS

B324374_S1.dwg



LIST OF MATERIAL

QUANT.	DESCRIPTION
AS REQ'D	CU. YDS. CONCRETE.
ONE	LOT OF REINF. FOR OUTLET WORKS & WINGWALL PER A-158186
2	SKIMMERS PER DETAILS ON DRAWING E-178080
ONE	48"Ø RODNEY HUNT FLAP VALVE SERIES FV-AC TEMP NO. B-048042 W/BRONZE SEATS AS MFG. BY RODNEY HUNT CO. ORANGE, MASS.
6	ANCHOR BOLTS "B1" PER DETAIL THIS DRAWING, SH. 2.
4	PCS. 60"Ø × 4'-0 LONG EXTRA STRENGTH R.C.P. - T & G.
110	LIN. FT. P.V.C. WATERSTOP #4316 AS MFG. BY W.R. MEADOWS OF PA., INC. YORK, PA. OR EQUAL.

NOTES

REINFORCING BARS TO BE INTERMEDIATE GRADE, DEFORMED STEEL BARS, CONFORMING TO ASTM A-615 - GRADE 60.

CONCRETE SHALL BE IN ACCORDANCE WITH THE AMERICAN CONCRETE INSTITUTE'S LATEST REVISION, AND DEVELOP A 28 DAY COMPRESSIVE STRENGTH OF 3000 PSI.

REFERENCE TITLE	NUMBER
NEW FLY ASH DISPOSAL BASIN #6	E-158595
LIST OF REINFORCING	A-158186
SKIMMER DETAILS	E-178080
POLISHING POND - PLAN & DETAILS	E-178085

FRACTIONAL SCALE — DECIMAL SCALE

NO. | DATE | ER. | REVISION | BY | CH. | APPROVED

F H 7 0 — LOC CODE

B S N 6 : O U T & W I N G W L P L N & S E C T — DESCRIPTION

ER-
ER- 102351
SCALE- AS SHOWN
DATE- 7-31-79
DRAWN- CDJ
CHECKED- GDL
LEADER-
APPRD-
APPRD-

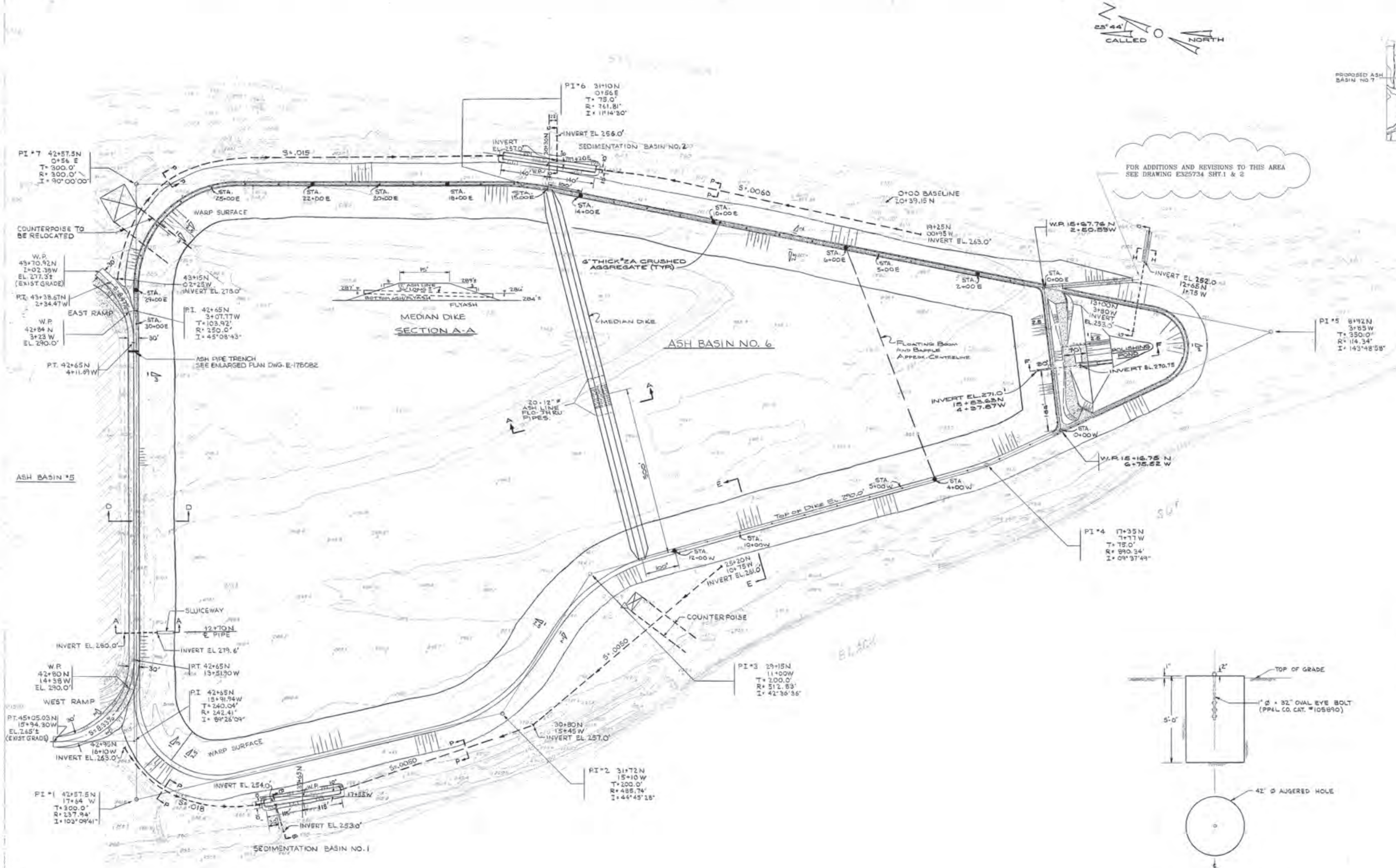
BRUNNER ISLAND S.E.S.
ASH BASIN #6
OUTLET WORKS & WINGWALL
PLANS, ELEVATIONS & SECTIONS

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA. No. 1 OF 2

APPROVED John A. Stefanik 7/31/79
RESPONSIBLE ENGINEER

C — SORT

D-158185-0



FLOATING ASHLINE ANCHOR LOCATION PLAN

+-100' STATIONS EAST (E) AND WEST (W) DIKES FOR ANCHOR LOCATION.

ANCHORS TO BE LOCATED JUST INSIDE GUARD RAIL EAST DIKE

ANCHOR LOCATION APPROXIMATE - TO BE FIELD LOCATED AWAY FROM GUARD RAIL POSTS, GATE POSTS, SUBSURFACE CABLES, AND CULVERTS.

● - SEVEN (7) ANCHORS EAST DIKE
● - TWO (2) ANCHORS WEST DIKE

BILL OF MATERIALS FOR NINE (9) ANCHORS

1/6 CUBIC YARDS 3000 PSI CONCRETE
9 - 1" Ø x 32" OVAL EYE BOLTS (PP&L CO CAT. # 105890)

DETAIL
TIE ANCHOR FOUNDATION
(TYPICAL)
FLOATING ASH LINE
UNIT 3

FOR NOTES & REFERENCES SEE SHEET NO. 2 THIS DWG.

REFERENCE TITLE	NUMBER
SOUTH ACCESS ROAD - PLAN & PROFILE	E-169157
ASH BASIN NO. 6 & POLISHING POND - PLAN & DETAILS	E-176088

NO	DATE	ER	REVISION	BY	CH	APPROVED
6	11/26/07		ADDED REFERENCE NOTE	DM		GDH
5	2/8/11	480251	ADDED FLOATING BOOM, MEDIAN DIKE, & SECTION A-A	KJK	JEM	AWS
4	11/18/86	103357	ADDED FLOATING ASH LINE ANCHOR FOUNDATIONS	JAC		
3	2/18/85	102851	ADDED ASH PIPE TRENCH REFERENCE	TJL	KBQ	
2	4/1/80	102718	REVISED ... SLUICEWAY TO POLISHING POND	GHC	FAC	LLH
1	6/8/77	102718	REVISED DIKE BETWEEN POLISHING POND AND ASH POND NO. 6, ADDED ACCESS RAMPS & GUARDRAIL	GHC	DPK	LLH

F H 7 0 | B I ASH BASIN NØ 6 PLAN 1

ER-102351
ER-
SCALE - 1"=100'
DATE - 1-23-76
DRAWN - EMB
CHECKED - ECB
LEADER - RCS
APPR'D - MMJ
APPR'D - JAB

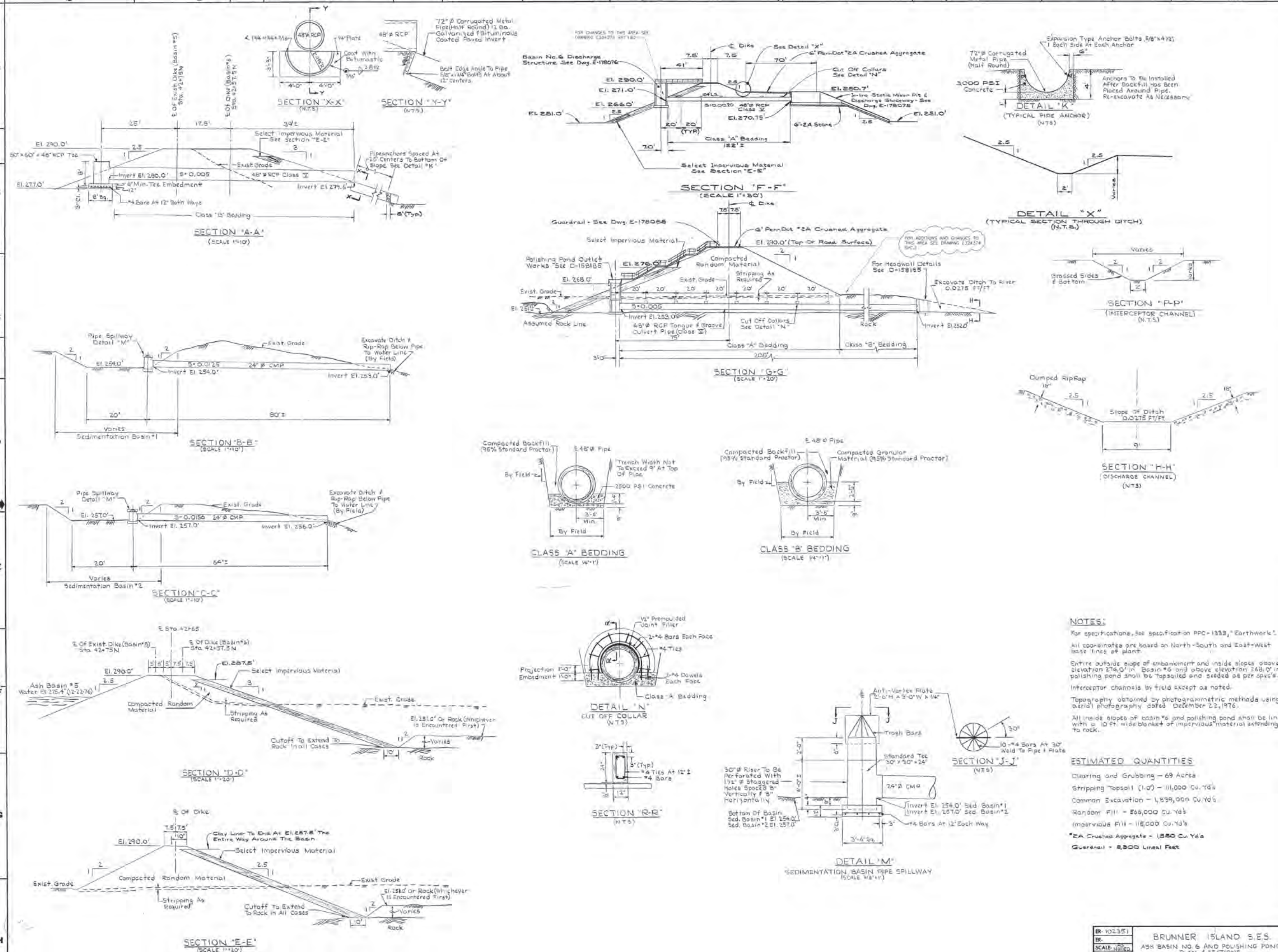
BRUNNER ISLAND S.E.S.
ASH BASIN NO. 6 AND POLISHING POND
PLAN & SECTIONS

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN PA.

SHEET 1 OF 7

APPROVED
RESPONSIBLE ENGINEER

E158595-6



NOTES:

For specifications, see specification PPC-1333, "Earthwork".

All coordinates are based on North-South and East-West base lines of plant.

Entire outside slope of embankment and inside slopes above elevation 274.0' in Basin #6 and above elevation 268.0' in polishing pond shall be topsoiled and seeded as per spec's.

Interceptor channels by field except as noted.

Topography obtained by photogrammetric methods using aerial photography dated December 22, 1976.

All inside slopes of basin #6 and polishing pond shall be lined with a 10 ft. wide blanket of impervious material extending to rock.

ESTIMATED QUANTITIES

Clearing and Grubbing — 69 Acres

Stripping Topsoil (1.0') — 111,000 Cu. Yd's

Common Excavation — 1,839,000 Cu. Yd's

Random Fill — 565,000 Cu. Yd's

Impervious Fill — 115,000 Cu. Yd's

#2A Crushed Aggregate — 1,580 Cu. Yd's

Guardrail — 8,300 Lineal Feet

REFERENCE TITLE	NUMBER
ASH STORAGE AREAS #4 & #5 - PLAN	LF-75333
ASH BASIN #6 & POLISHING POND - OUTLET WORKS & HEADWALL	C-158185
ASH BASIN #7 - PLAN & SECTIONS	E-157640
ASH BASIN #6 - LOCATION & LOG OF CORE DRILL HOLES	D-129687

REFERENCE TITLE	NUMBER
BILL OF MATERIAL	A-159148

NO.	DATE	ER.	REVISION	BY	CH.	APPROVED
4	11/26/03		ADDED REFERENCE NOTE TO SECTION G-G	DM		GDH
3	11/20/06		ADDED NOTE TO SECTION F-F	DM		GDH

NO.	DATE	ER.	REVISION	BY	CH.	APPROVED
2	4/3/80	102713	ADDED IN-LINE STATIC MIXER PIT DISCHARGE SLUICEWAY, REVISED INV. & LENGTH OF 48" RCP IN SECT. F-F & DELETED DETAIL "Y".	SHC	FAC	ALN
1	6/8/79	102713	REVISED DETAIL "K" AND ADDED DETAIL "Y".	SHC	DPK	ALN
			ADDED GUARD RAIL & AGGREGATE QUANTITIES & DET. "X"			
			REVISED SECT. "F-F" & CLAY IN SECT. "D-D", "E-E" & "G-G".			

LOC CODE: F H 7 0 | DESCRIPTION: BI ASH BASIN NO 6 PLAN 2 | SORT: C

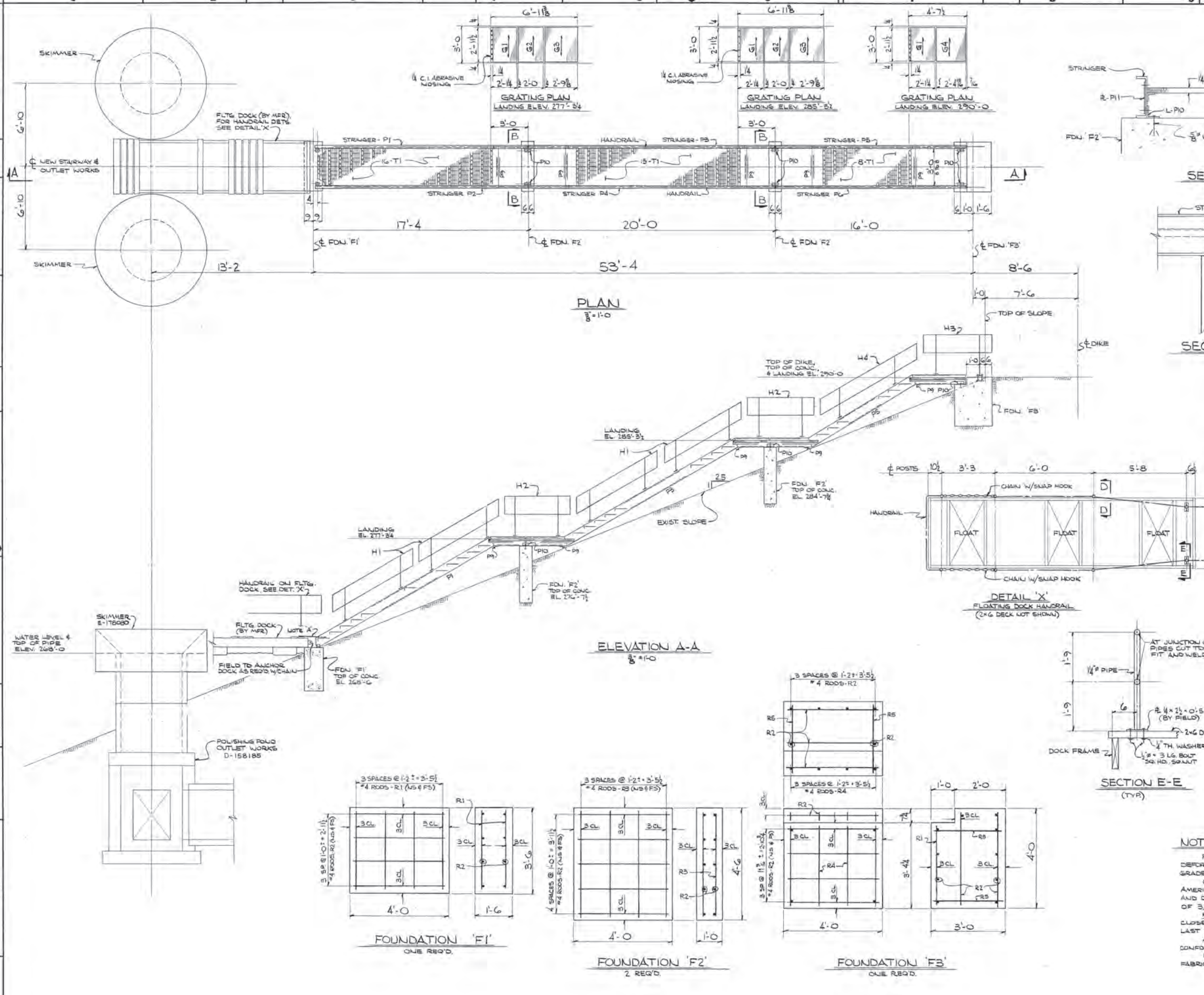
ER- 102351
ER-
SCALE- AS NOTED
DATE- 1-23-78
DRAWN- EMB
CHECKED- RCB
LEADER- RCS
APPR'D- NHJ
APPR'D- JAE

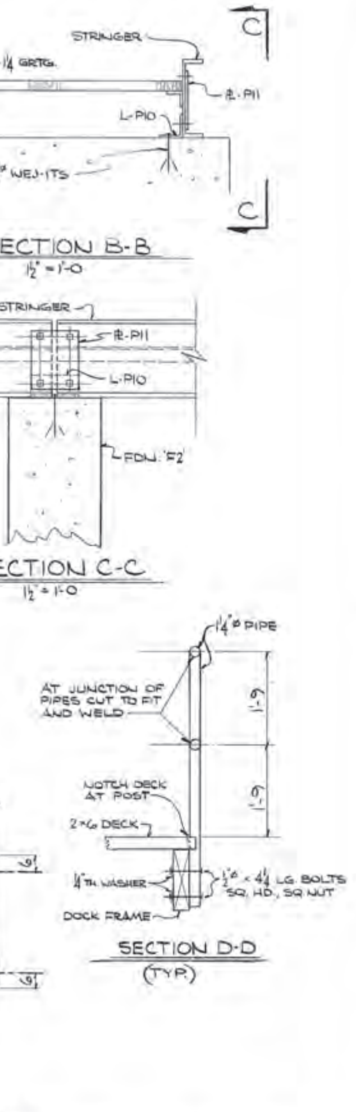
BRUNNER ISLAND S.E.S.
ASH BASIN NO. 6 AND POLISHING POND
PLAN & SECTIONS

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA.
SHEET 2 OF 2

RESPONSIBLE ENGINEER

E158595-4





LIST OF MATERIAL	
QTY.	DESCRIPTION
ONE	LOT OF MATERIAL PER DETAILS ON D-175191, SHTS 1 & 2
ONE	LOT OF REINFORCING RODS PER DETS. ON A-170416
170	3/8"⌀ × 1½ LG. BOLTS, HEX. HD., HEX. NUT
170	PALNUTS FOR 3/8"⌀ BOLTS
14	5/8"⌀ × 1½ LG. BOLTS, HEX. HD., HEX. NUT
75	5/8"⌀ × 1¾ LG. BOLTS, HEX. HD., HEX. NUT
89	PALNUTS FOR 5/8"⌀ BOLTS
14	5/8"⌀ × 0'-5 LG. WEJ-IT ANCHORS
15	½"⌀ × 4¼ LG. BOLTS, SQ. HD., SQ. NUT W/¼" WASHER
5	½"⌀ × 3 LG. BOLTS, SQ. HD., SQ. NUT W/¼" WASHER
100	LIN. FT. 1¼"⌀ SCHED. 40 PIPE (BLACK)
AS REQD	CONC.
AS REQD	SNAP HOOKS & CHAIN (BY FIELD)
AS REQD	℞ ¼ × 2½ × 0'-5 (BY FIELD)
ONE	CHECKERED ℞ ¼ × 2'-0 × 2'-11½ (BY FIELD - NOTE "A")
AS REQ'D	PAINT FOR DOCK & ATTACHED HANDRAIL

NOTES

REINFORCING BARS TO BE INTERMEDIATE GRADE, DEFORMED STEEL BARS, CONFORMING TO ASTM A-615-GRADE 60.

CONCRETE SHALL BE IN ACCORDANCE WITH THE AMERICAN CONCRETE INSTITUTE'S LATEST REVISION. AND DEVELOP A 28 DAY COMPRESSIVE STRENGTH OF 3,000 PSI.

NOTE "A" - FIELD TO PROVIDE CHECKERED ℞ TO CLOSE OPENING AT BOTTOM OF STAIRS (BETWEEN LAST STEP AND DOCK) FASTEN BY FIELD TO SUIT.

ALL BOLTS TO BE REGULAR STRENGTH, CONFORMING TO ASTM A394 & GALVANIZED.

DOCK & HANDRAIL TO BE PAINTED AFTER FABRICATION, BY FIELD TO SUIT.

REFERENCE TITLE	NUMBER
SHOP DETAILS	D-175191
OUTLET WORKS & WINGWALL	D-158185
PLAN & SECTIONS	E-158595
POLISHING POND - PLAN & DETAILS	E-178085

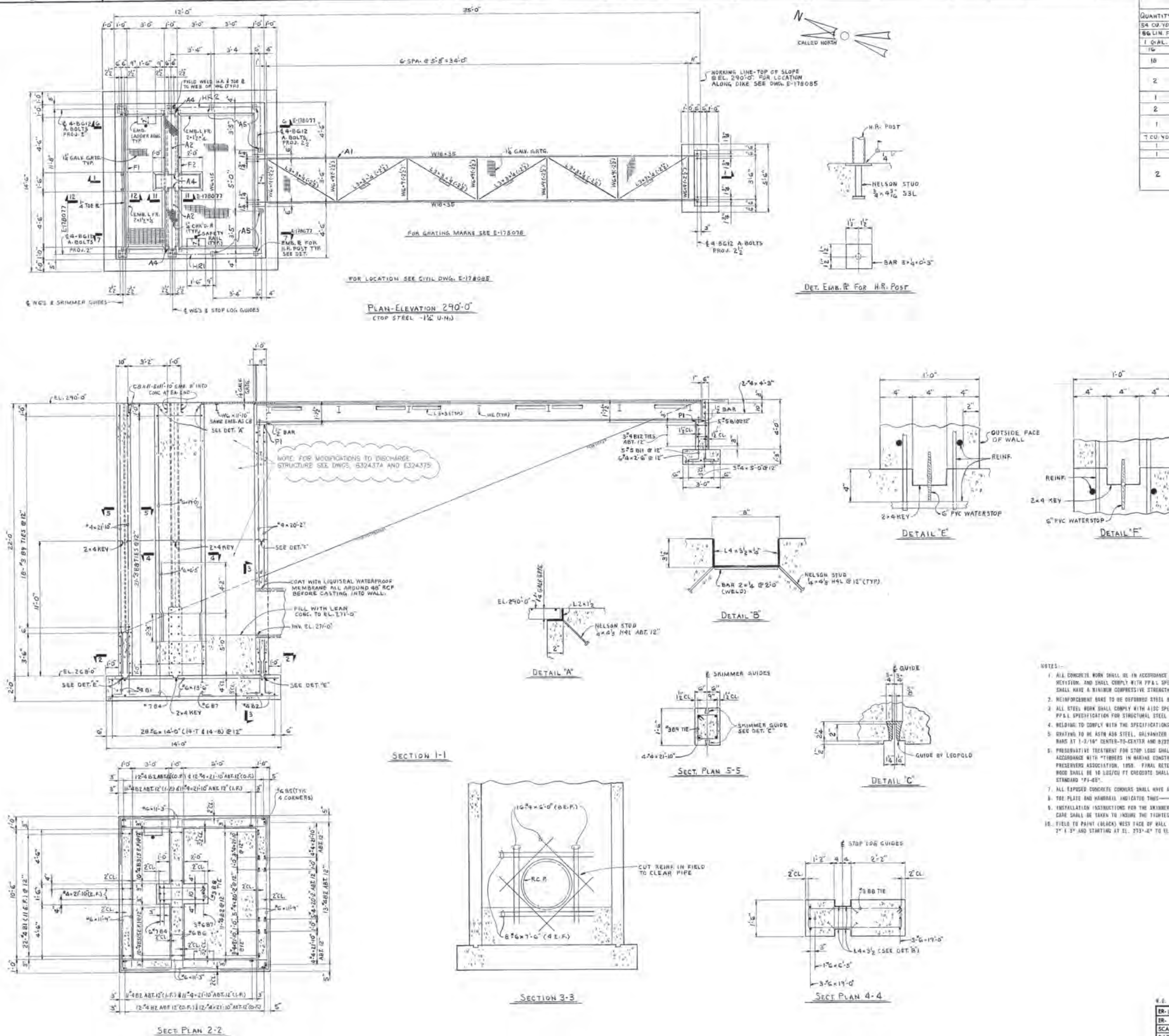
ER-102351
ER-
SCALE-AS NOTED
DATE-7-31-79
DRAWN-WBM
CHECKED-
LEADER-
APPR'D-
APPR'D-

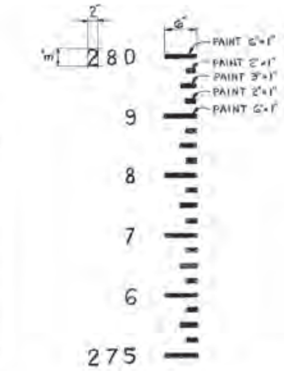
BRUNNER ISLAND S.E.S.
ASH BASIN #6
ACCESS TO POLISHING POND OUTLET WORKS ASSEMBLY & DETAILS

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA.

APPROVED 7/31/79
RESPONSIBLE ENGINEER

E-175190-0




DETAIL "G"
(SEE NOTE 10)

BILL OF MATERIALS	
QUANTITY	DESCRIPTION
54 CU. YDS.	3,000 P.S.I. CONCRETE
86 LIN. FT.	6" PVC WATERSTOP TYPE NO. 6380 W.R. MEADOWS OR EQUAL
1 GAL.	LIQUISEAL WATERPROOF MEMBRANE BY SURE SEAL
16	⅝"ø A. BOLTS BG12 AS PER SHEET NO. 9 OF LA-80165
18	LOGS LONGLEAF YELLOW PINE SELECT STRUCT. GRADE SEE STOP LOG DET. (E-178077) & NOTE 6
2	SKIMMER GATE, FIBERGLASS REINFORCED POLYESTER RESIN, 4'-0" H. x 4'-6" W., COMPLETE WITH 18'-6" H. TYPE EP-103 FRAME, LIFT BOLTS, AND 25 L.F. ⅜" STAINLESS STEEL CABLE. GATE TO HAVE NEOPRENE SEAL STRIPS. AS MANUFACTURED BY F.B. LEOPOLD CO., ZELIENOPLE, PA.
1	FOUR WHEEL I BEAM TROLLEY FOR 8" I BEAM, 4,000 LBS. CAPACITY. McMASTER-CARR CO. NO. 3267T4 OR EQUAL
2	WORM GEAR WINCH 2000 LBS. CAPACITY, McMASTERS-CARR NO. 3210T14 OR EQUAL
1	CABLE RATCHET WINCH HOIST, 4,000 LBS. CAPACITY. 25' LIFT WITH SAFETY HOOKS AND STAINLESS STEEL CABLE DETACHABLE HANDLE MARINE SERVICE, LUG ALL MODEL 450-8-M OR EQUAL
7 CU. YDS.	LEAN CONC.
1	LOT OF STEEL & GRTG. AS PER E-178078 & E-178079
1	LOT OF REINF. STEEL AS PER A-178084 SHTS 3 & 4
2	LADDER FALL PREVENTION DEVICE COMPLETE WITH CARRIER RAIL, LADDER RUNG CLAMPS, SLEEVE, AND 4'-6" REMOVABLE TOP EXTENSION, ALL GALVANIZED. ONE ASSEMBLY 26' LONG ONE ASSEMBLY 23' LONG. NORTON COMPANY "SAF-T-CLIMB" OR EQUAL.

NOTES:-

1. ALL CONCRETE WORK SHALL BE IN ACCORDANCE WITH THE AMERICAN CONCRETE INSTITUTE CODE LATEST REVISION, AND SHALL COMPLY WITH PP&L SPECIFICATION FOR CONCRETE LA-50166, EXCEPT CONCRETE SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH OF 3000 PSI AT THE END OF 28 DAYS.
2. REINFORCEMENT BARS TO BE DEFORMED STEEL BARS CONFORMING TO ASTM A615, GRADE 60.
3. ALL STEEL WORK SHALL COMPLY WITH AISC SPECIFICATIONS AND CODE OF STANDARD PRACTICE AND PP&L SPECIFICATION FOR STRUCTURAL STEEL LA-50165 AND SHALL CONFORM TO ASTM A36.
4. WELDING TO COMPLY WITH THE SPECIFICATIONS OF THE AMERICAN WELDING SOCIETY.
5. GRATING TO BE ASTM A36 STEEL, GALVANIZED AS PER ASTM A123-73, WITH 1-1/4" X 1/4" BEARING BARS AT 1-3/16" CENTER-TO-CENTER AND 5/32" CROSS BARS AT 4" CENTER-TO-CENTER.
6. PRESERVATIVE TREATMENT FOR STOP LOGS SHALL BE PRESSURE CREOSOTING AND SHALL BE DONE IN ACCORDANCE WITH "TIMBERS IN MARINE CONSTRUCTION SPECIFICATION C-18" OF THE AMERICAN WOOD PRESERVERS ASSOCIATION, 1958. FINAL RETENTION OF GRADE NO. 1 CREOSOTE PER CUBIC FOOT OF WOOD SHALL BE 16 LBS/CU FT CREOSOTE SHALL CONFORM TO AMERICAN WOOD PRESERVERS ASSOCIATION STANDARD "P1-65".
7. ALL EXPOSED CONCRETE CORNERS SHALL HAVE A 3/4" CHAMFER.
8. TOE PLATE AND HANDRAIL INDICATED THUS
9. INSTALLATION INSTRUCTIONS FOR THE SKIMMER GATE AND GUIDE SHALL BE SUPPLIED BY F.B. LEOPOLD COMPANY CARE SHALL BE TAKEN TO INSURE THE TIGHTEST SEAL POSSIBLE WITH THE MATERIAL PROVIDED.
10. FIELD TO PAINT (BLACK) WEST FACE OF WALL (NORTHWEST CORNER) WITH A GRADUATED SCALE WITH FIGURES 2" X 3" AND STARTING AT EL. 273'-6" TO EL. 280'-0" AS SHOWN IN DETAIL "G".

REFERENCE TITLE	NUMBER	REFERENCE TITLE	NUMBER
ASH BASIN #6 DISCH. STRUCTURE STRL. CONC. & STL. SECT. & DET.	E-178077	LIST OF REINFORCING SHEETS 3 & 4	A-178084
LAYOUT OF DIKE BETWEEN ASH POND #6 & POLISHING POND CIVIL	E-158595		
STEEL DETAILS	E-178078		
STEEL DETAILS	E-178079		

NO.	DATE	ER.	REVISION	BY	CH.	APPROVED
(2)	10/23/09		REVISED REFERENCE NUMBER (D3)	DM		
1	11/06		ADDED NOTE FOR DISCHARGE STRUCTURE (D3)	DM		

W.O. 844712-841

ER- 132951
ER-
SCALE- 3/8"=1'-0"
DATE- 6/8/79
DRAWN- N.K.
CHECKED- L.P.H. 5.16.79
LEADER- J.J.F.
APPR'D-
APPR'D-

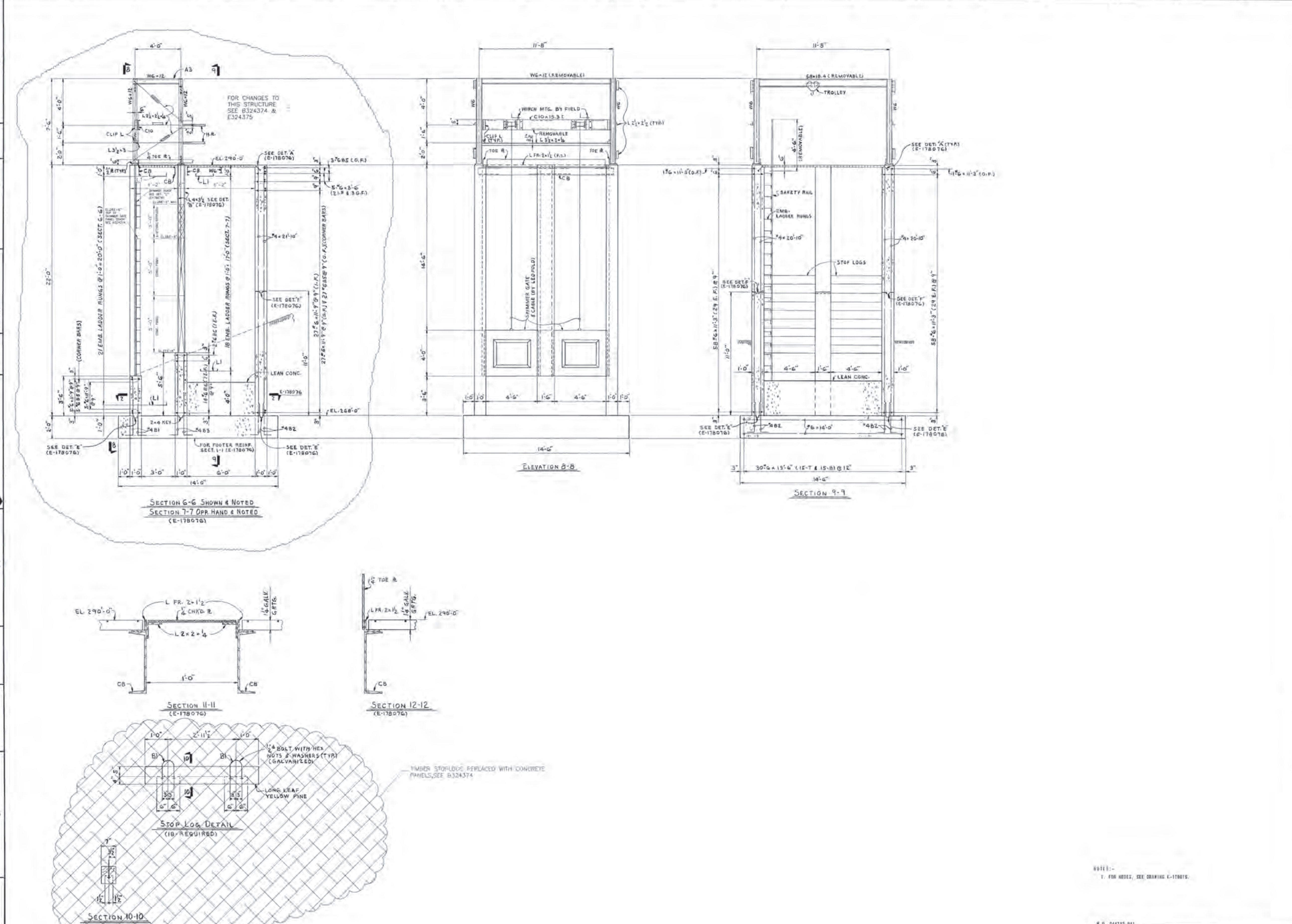
BRUNNER ISLAND S. E. STATION
ASH BASIN 6 DISCHARGE STRUCTURE
STRUCTURAL CONCRETE AND STEEL
PLAN AND SECTIONS

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA.

APPROVED J.A. Stefanik 6/8/79
RESPONSIBLE ENGINEER

SHT. 1
E178076-2

E H70 DISCH. STRUCT. PLAN & SECTS.
5 SORT



NOTES:-
1. FOR NOTES, SEE DRAWING E-178076.

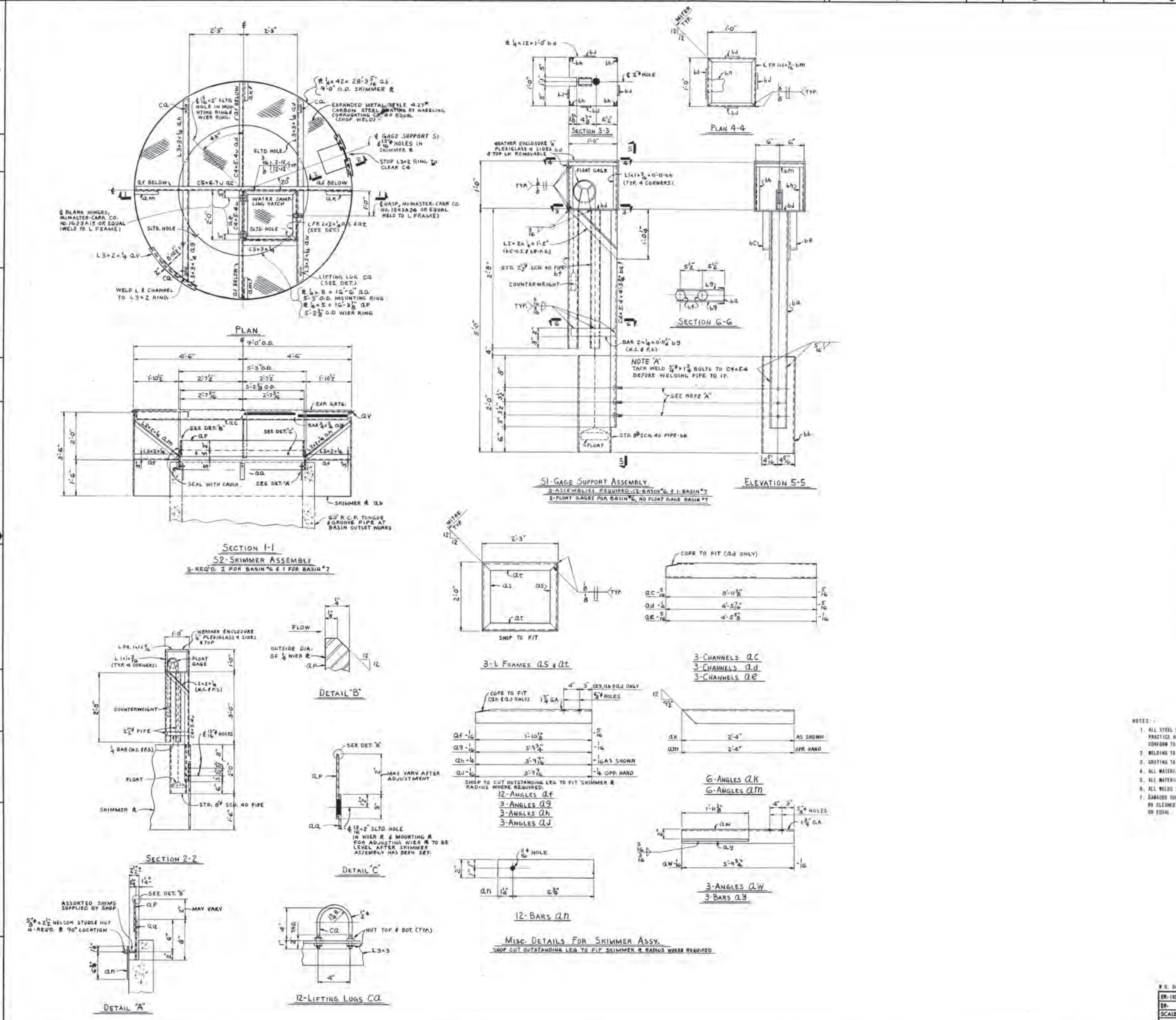
W.O. 044712-041

ER-102351	BRUNNER ISLAND S. E. STATION
ER-	ASH BASIN #8 DISCHARGE STRUCTURE
SCALE-3/8"=1'-0"	STRUCTURAL CONCRETE AND STEEL
DATE-6/9/77	SECTIONS AND DETAILS
DRAWN- N.K.	
CHECKED- LFH	PENNSYLVANIA POWER & LIGHT COMPANY
LEADER- J.J.F.	ALLENTOWN, PA.
APPR'D-	APPROVED J. A. Stefanik 6/9/79 RESPONSIBLE ENGINEER
APPR'D-	E178077-1 SHT. 1

REFERENCE TITLE	NUMBER	REFERENCE TITLE	NUMBER
ASH BASIN #8 DISCH. STRUCTURE STRL. CONC. & STL. PLAN & SECT.	E-178076		

NO.	DATE	ER.	REVISION	BY	CH.	APPROVED
1	11/06		REVISED SECTION 6-6 & 7-7(CD)	DM	ODH	

DISCH. STRUCT. SECTS & DETS.



Shop Bill

Line	Assy. Mark	No	Shape	Section: Size	Section: Size or Pounds	Section: Thick	Length: Ft.	Length: In.	Remarks
	3-ASSEMBLIES S1, (2-BASIN #6 & 1-BASIN #7)								
1	ba	3	C	4	5.4		4	$5\frac{3}{4}$	
2	bb	3	STD. 8"φ	PIPE			2	0	SCH. 40
3	bc	3	L	2	2	$\frac{1}{4}$	1	5	
4	bd	3	℞	12		$\frac{1}{4}$	1	0	
5	be	3	L	2	2	$\frac{1}{4}$	1	5	
6	bf	6	STD. $2\frac{1}{2}$"φ	PIPE			2	8	SCH. 40
7	bg	6	BAR	2		$\frac{1}{4}$	0	$11\frac{1}{4}$	
8	bh	12	L	1	1	$\frac{3}{16}$	0	11	
9	bj	12	SHT	12		$\frac{1}{4}$	1	$0\frac{1}{4}$	PLEXIGLASS
10	bk	3	SHT	$12\frac{1}{2}$		$\frac{1}{4}$	1	$0\frac{1}{2}$	PLEXIGLASS
11	bm	12	L	1	1	$\frac{3}{16}$	1	0	L FRAME
12		2	STEVENS FLOAT GAGES PART						BASIN #6
13			NO. 15112 BY LEUPOLD & STEVENS						
14			INC., BEAVERTON, OREGON						
15		2	6" FLOATS W/8 OZ. COUNTERWEIGHT						BASIN #6
16			BY LEUPOLD & STEVENS INC. PART						
17			NO. 20447-22673						
18		2	FLOAT TAPES BY LEUPOLD &						BASIN #6
19			STEVENS INC. PART NO.						
20			20838-15147						
21		9	307	$\frac{3}{4}$			0	$1\frac{3}{4}$	GALV. BOLTS
22									
23									
24									
25									
26	3-SKIMMER ASSY. S2 (2-BASIN #6 & 1-BASIN #7)								
27									
28	aa	3	℞	8		$\frac{1}{4}$	16	6	RING 5'-3" O.D.
29	ab	3	℞	42		$\frac{1}{4}$	28	$3\frac{5}{16}$	RING 9'-0" O.D.
30	ac	3	C	5	6.7		8	$11\frac{3}{8}$	
31	ad	3	C	4	5.4		4	$5\frac{7}{16}$	
32	ae	3	C	4	5.4		4	$5\frac{5}{8}$	
33	af	12	L	3	2	$\frac{1}{4}$	1	$10\frac{1}{8}$	
34	ag	3	L	3	3	$\frac{1}{4}$	3	$9\frac{3}{4}$	
35	ah	3	L	3	3	$\frac{1}{4}$	3	$9\frac{9}{16}$	
36	aj	3	L	3	3	$\frac{1}{4}$	3	$9\frac{9}{16}$	
37	ak	6	L	2	2	$\frac{1}{4}$	2	4	
38	am	6	L	2	2	$\frac{1}{4}$	2	4	
39	an	12	BAR	2		$\frac{1}{4}$	0	8	
40	ap	3	℞	5		$\frac{1}{4}$	16	$3\frac{7}{8}$	RING 5'-$2\frac{5}{8}$" O.D.
41	as	6	L	2	2	$\frac{1}{4}$	2	0	L FRAME
42	at	6	L	2	2	$\frac{1}{4}$	2	3	L FRAME
43		6	BLANK HINGES, McMASTER-CARR						
44			CO. NO. 1623A15 OR EQUAL						
45		3	HASPS, McMASTER-CARR CO.						
46			NO. 1543A24 OR EQUAL						
47		12	NELSON STUDS & NUTS $\frac{5}{8}$"φ x $2\frac{1}{2}$"						PART NO. 101-017-379
48		81	SQ. FT. EXPANDED METAL STYLE						
49			4.27# CARBON STEEL GRATING BY						
50			WHEELING CORRUGATING Co. OR EQUAL						
51	av	3	L	3	2	$\frac{1}{4}$	27	$10\frac{9}{16}$	RING 8'-$10\frac{1}{2}$" I.D.
52	aw	3	L	3	3	$\frac{1}{4}$	3	$9\frac{3}{4}$	
53	ay	3	BAR	$\frac{3}{4}$		$\frac{3}{4}$	1	$11\frac{7}{8}$	
54	ca	12	BAR	$\frac{1}{2}$"φ			1	2	48-HEX NUTS
55									
56									
57									
58									

NOTES:-

1. ALL STEEL WORK SHALL COMPLY WITH AISC SPECIFICATIONS AND CODE OF STANDARD PRACTICE AND PP&L SPECIFICATION FOR STRUCTURAL STEEL LA-50165 AND SHALL CONFORM TO ASTM A36.
2. WELDING TO COMPLY WITH THE SPECIFICATIONS OF THE AMERICAN WELDING SOCIETY.
3. GRATING TO BE GALVANIZED AS PER ASTM A123-73.
4. ALL MATERIAL TO BE FURNISHED ASSEMBLED.
5. ALL MATERIAL TO BE GALVANIZED AFTER WELDING.
6. ALL WELDS 1/4" FILLET WELD ALL AROUND, UNLESS NOTED.
7. DAMAGED SURFACES OF GALVANIZED STEEL DUE TO FIELD WELDING OR CUTTING SHALL BE CLEANED AND PAINTED WITH "GALVANOX" TYPE I AS MANUFACTURED BY SUBOX, INC. OR EQUAL.

Reference Title	Number
ASH BASIN #6 PLAN & SECTIONS	E-150595
ASH BASIN #6 OUTLET WORKS	D-158185
ASH BASIN #7 PLAN & SECTIONS	E-167540

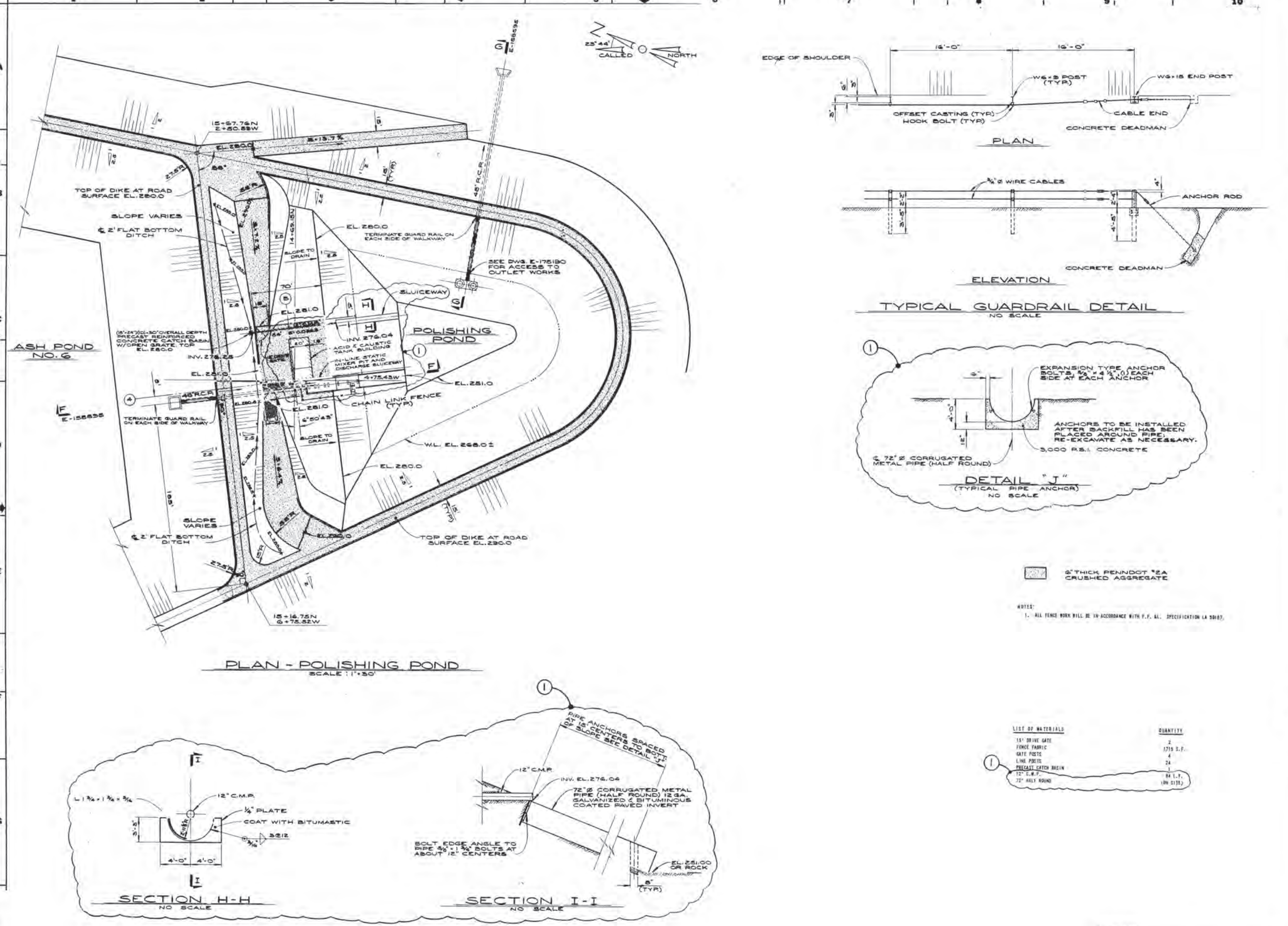
W.O. 044712-041
ER-102351
ER-
SCALE- VARIES
DATE- 2-3-77
DRAWN- N. K.
CHECKED- LRG
LEADER- J.J.R.
APPR'D-
APPR'D-

BRUNNER ISLAND S. E. STATION
ASH BASINS 6 AND 7
SKIMMER AND FLOAT GAGE
SHOP DETAILS AND LIST OF MATERIALS

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA.

APPROVED John A. Stoford 2/4/77
RESPONSIBLE ENGINEER

E-178080-0



REFERENCE TITLE	NUMBER	REFERENCE TITLE	NUMBER
SWITCHYARDS & SUBSTATIONS - PROPERTY FENCE	LD-3586	ASH BASIN #6 - ACCESS TO POLISHING POND OUTLET	E-175190
ASH BASIN #6 & POLISHING POND - OUTLET WORKS & HW.	D-168188		
INLINE MIXER FOUNDATION - PLAN & SECTIONS	D-178075		
ASH BASIN #6 & POLISHING POND - PLAN & SECTIONS	E-168688		

W.O. 044712-042

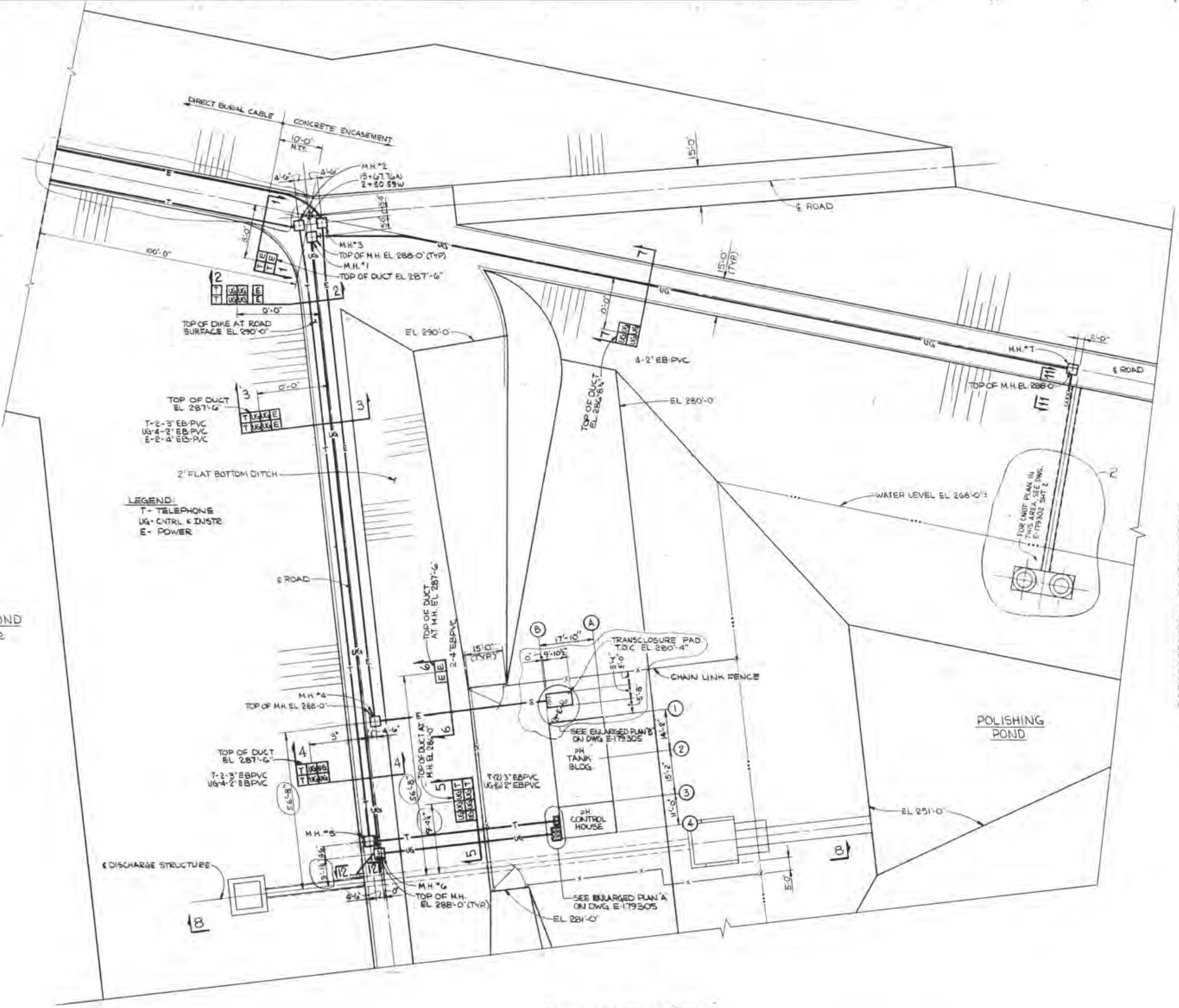
ER- 102713
SCALE- 1"=30'
DATE- 6/5/79
DRAWN- G.H.C.
CHECKED- DFK
LEADER- K.L.M.

BRUNNER ISLAND S.E.S.
ASH BASIN NO. 6 - POLISHING POND
ENLARGED PLAN

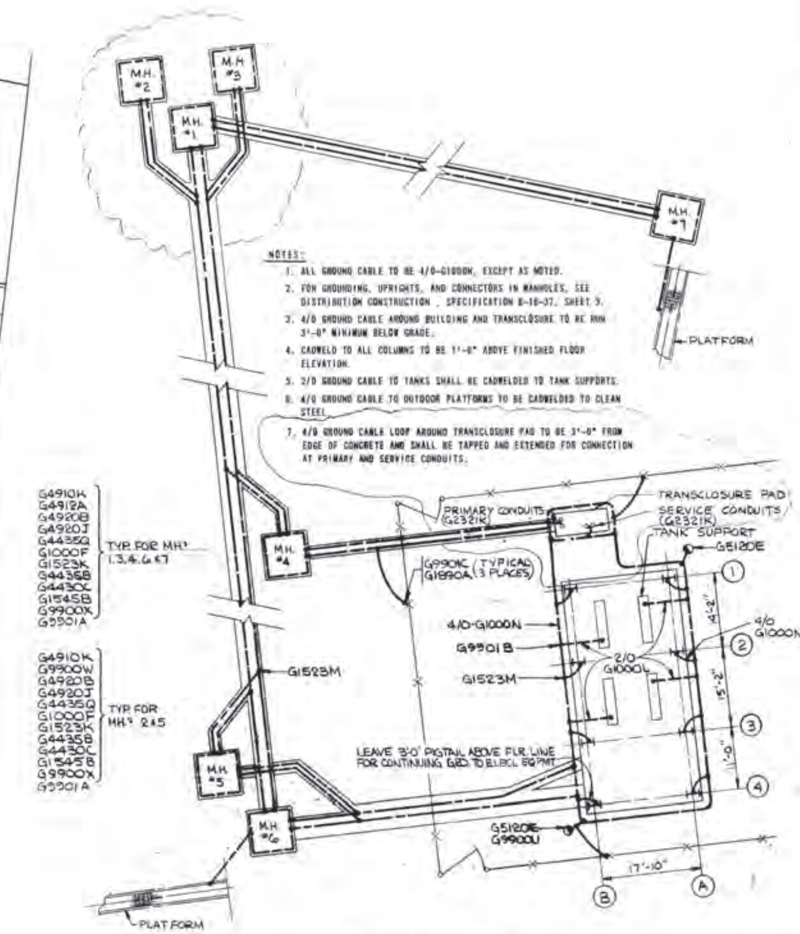
PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA.

APPROVED John A. Stefanek

E-178085-1



PLAN - POLISHING POND
SCALE: 1/16" = 1'-0"



NOTES:

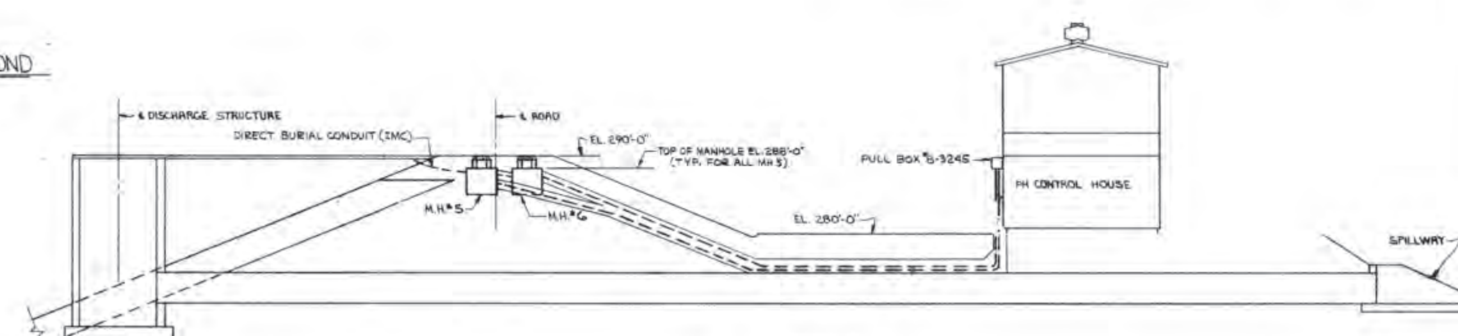
1. ALL GROUND CABLE TO BE 4/0-G1000N, EXCEPT AS NOTED.
2. FOR GROUNDING, UPRIGHTS, AND CONNECTORS IN MANHOLES, SEE DISTRIBUTION CONSTRUCTION, SPECIFICATION 8-18-37, SHEET 3.
3. 4/0 GROUND CABLE AROUND BUILDING AND TRANSCLOSURE TO BE MIN 3'-0" MINIMUM BELOW GRADE.
4. CADWELD TO ALL COLUMNS TO BE 1'-0" ABOVE FINISHED FLOOR ELEVATION.
5. 2/0 GROUND CABLE TO TANKS SHALL BE CADWELDED TO TANK SUPPORTS.
6. 4/0 GROUND CABLE TO OUTDOOR PLATFORMS TO BE CADWELDED TO CLEAN STEEL.
7. 4/0 GROUND CABLE LOOP AROUND TRANSCLOSURE PAD TO BE 3'-0" FROM EDGE OF CONCRETE AND SHALL BE TAPPED AND EXTENDED FOR CONNECTION AT PRIMARY AND SERVICE CONDUITS.

GROUNDING PLAN
SCALE: NONE

NOTES:

INSTALLATION

1. MANHOLE - DISTRIBUTION CONSTRUCTION SPECIFICATION 8-15-67 AND 8-15-66.
2. MANHOLE FRAME AND COVER - DISTRIBUTION CONSTRUCTION SPECIFICATION 8-15-08 AND 8-15-08.
3. UNDERGROUND DUCTS (ENCASED) - DISTRIBUTION CONSTRUCTION SPECIFICATION 8-15-81, SHEET 1 THROUGH 10.
4. ALL DIRECT BURIAL CONDUITS (IMC) AND EXTERIOR OF MANHOLES BELOW GRADE TO BE COATED WITH TWO COATS OF FARBERTITE (C), A COAL PITCH DERIVATIVE AS PER MANUFACTURERS DIRECTIONS. FARBERTITE (C) PROTECTS AGAINST MOISTURE AND CHEMICAL CORROSION AND IS MANUFACTURED BY BRIGGS BITUMINOUS COMPOSITION COMPANY, B/M G8801A.



SECTION "8-8"
SCALE: 1/8" = 1'-0"

REFERENCE TITLE	NUMBER	REFERENCE TITLE	NUMBER
BILL OF MATERIAL SH 1752 TO 1765	LA-50942		
ASH BASIN 6-PH CONT. FACILITY CONDUIT LAYOUT & CAUSTIC TANK BLDG	E-179302		
ASH BASIN 6-PH CONT. FACILITY SECTIONS & DETAILS MANHOLES & UGND. DUCTS	E-179305		
ASH BASIN 6-POLISHING POND-ENLARGED PLAN	E-178085	ASH BASIN 6 DISCH. STRUCTURE - PLAN STEEL	E-178076

NO.	DATE	ER.	REVISION	BY	CH.	APPROVED		
2	12/8/80	102713	ADDED REFERENCE AS IND.	JPS	JMA		WIP	
1	9-24-80	102713	REV. T-PAD & RELOCATED MH #4 & #6, REV. GRDNG @ T-PAD / ADDED NOTE 7	EEE	RAY	WIP		

LOC CODE: F3D70 DESCRIPTION: CNTRL FAC MH UG GRDNG PLN SORT: E

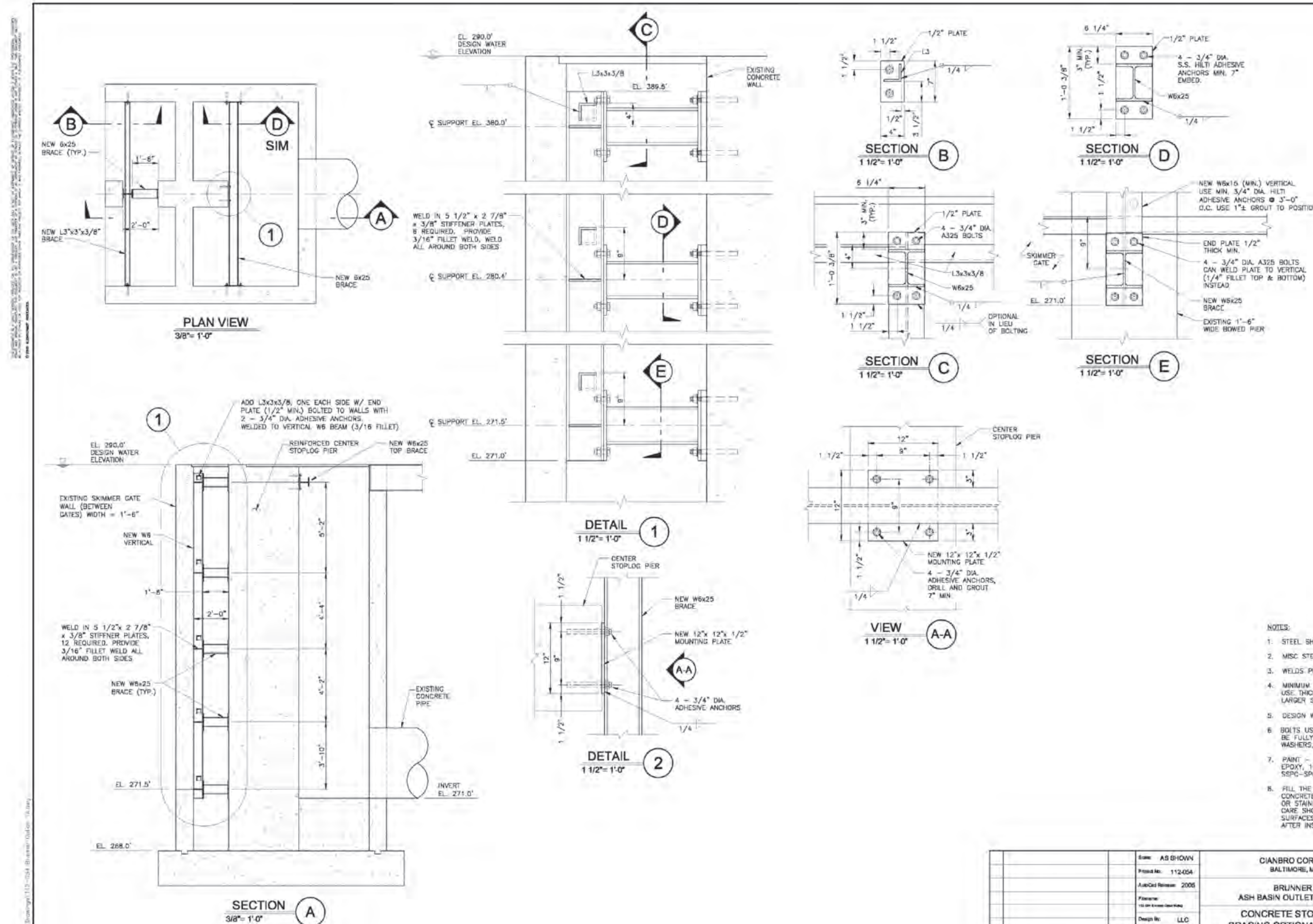
W.O. 044712-042
ER-102713
ER-
SCALE-AS NOTED
DATE- 8-8-80
DRAWN- T.J.W.
CHECKED- EEK
LEADER- RAY
APPR'D-
APPR'D-

BRUNNER ISLAND S. E. STATION
ELECTRICAL
ASH BASIN 6, pH CONTROL FACILITY
PLAN
MANHOLES - UNDERGROUND DUCTS - GROUNDING

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA.

APPROVED
SENIOR PROJECT ENGINEER

E-179301-2



NOTES:

1. STEEL SHAPES: A992 GRADE 50
2. MISC STEEL PLATE: A36 MIN.
3. WELDS PER AWS D1.1, E70XX ELECTRODES.
4. MINIMUM SIZES AND THICKNESS SHOWN, CAN USE THICKER PLATES AND LARGER PLATES AND LARGER SIZES IF DESIRED.
5. DESIGN WATER EL 290.0'.
6. BOLTS USED IN SLOTTED HOLE CONNECTION TO BE FULLY TIGHTENED, HAVE LOAD INDICATING WASHERS, OR TWIST-OFF BOLTS.
7. PAINT – SHERWIN WILLIAMS TARGUARD COAL TAR EPOXY, 10 TO 16 MILS DPT, SURFACE PREP SSPC-SP6, OR APPROVED EQUAL.
8. FILL THE SPACE BETWEEN STEEL AND EXISTING CONCRETE FOR A SNUG UNIFORM FIT. USE GROUT OR STAINLESS STEEL SHIMS. IF SHIMS ARE USED, CARE SHOULD BE TAKEN NOT TO MAR PAINTED SURFACES. TOUCHUP PAINT AS NECESSARY AFTER INSTALLATION.

No.	Revision	Date		
			Scale: AS SHOWN	CIANBRO CORPORATION BALTIMORE, MARYLAND
			Project No: 112-054	
			AutoCad Release: 2006	BRUNNER ISLAND ASH BASIN OUTLET MODIFICATIONS
			Filename:	
			Design By: LLC	CONCRETE STOPLOG PANEL BRACING OPTIONAL NEW SYSTEM
			Drawn By: HWF	Kleinschmidt Energy & Water Resource Consultants 75 Main St. P.O. Box 576 Pittsfield, Maine 04967 Telephone: (207) 487-3328 Fax: (207) 487-3124 www.KleinschmidtUSA.com
			Checked By: LLC	
			Date Revised: 1-25-06	

FOR REVIEW AND COMMENT 1-25-06

1A

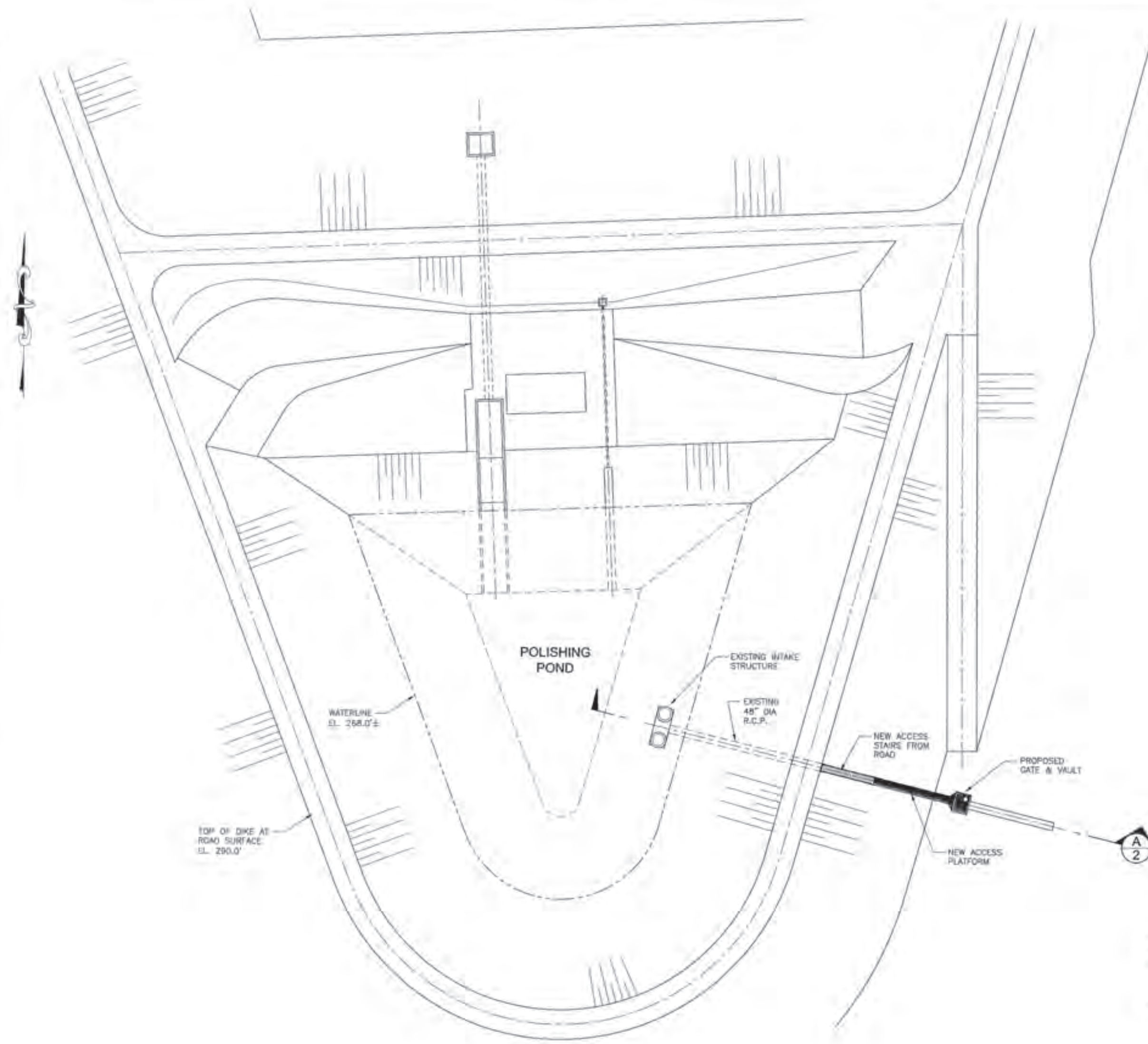
BRUNNER ISLAND S.E.S.
ASH BASIN OUTLET MODIFICATIONS
CONCRETE STOPLOG PANELS
BRACING RETRO FIT
PLAN SECTIONS AND DETAILS

PPL CORP.

E324375

1

0



SITE PLAN
1"= 30'

30 0 30 60
SCALE IN FEET

GENERAL CONCRETE NOTES

1.) NEW CONCRETE VAULT CAN EITHER BE CAST-IN-PLACE OR PRE-CAST. PRE-CAST DESIGN SHALL BE SUBMITTED FOR APPROVAL.

2.) ALL LOOSE ROCK AND MUCK SHALL BE REMOVED PRIOR TO CONSTRUCTION. WHEN CONCRETE IS PLACED DIRECTLY AGAINST ROCK SURFACES, THE SURFACE SHALL BE CLEANED WITH HIGH PRESSURE WATER TO REMOVE ALL DIRT OR LOOSE MATERIAL. HIGH PRESSURE WATER IS DEFINED FOR THIS PURPOSE AS 1,500 PSI MINIMUM. IF GREASE, OIL OR OTHER COATINGS ARE ON THE ROCK SURFACE, OTHER METHODS MAY BE REQUIRED FOR REMOVAL.

3.) SURFACE PREPARATION OF EXISTING CONCRETE AND MASONRY SURFACES SHALL REMOVE LOOSE DETERIORATED MATERIAL AND VEGETATION. ACCEPTABLE METHODS INCLUDE: SANDBLASTING, MECHANICAL CHIPPING OR HIGH PRESSURE WATER BLAST (6,000 psi MIN.).

4.) EXCEPT AS OTHERWISE NOTED:

A. CONCRETE: 4000 PSI @ 28 DAYS, AIR ENTRAINED 5% TO 7%

B. REINFORCEMENT: 60,000 PSI, ASTM A615

C. REBAR COVER: 2" UNLESS NOTED OTHERWISE

MODES – ACI STANDARD
SPLICES – #7 BAR = 54"
– #5 BAR = 31"
– #4 BAR = 25"

D. CONCRETE ANCHORS: 3/4" MIN. DIA. S.S. SIMPSON EPOXY-TIE FOR DAMP OR SUBMERGED APPLICATIONS OR APPROVED EQUAL

E. GROUT: 5000psi NON-SHRINK GROUT @ 28 DAYS CRD-C621

5.) PROVIDE ADHESIVE WATERSTOPS OF WATER SWELLING ELASTIC SEALING MATERIAL WHERE INDICATED. END ALL WATERSTOP 3"± FROM EXPOSED FINISHED CONCRETE SURFACE. ACCEPTABLE SUPPLIERS: WATERSTOP RX. INSTALL PER MANUFACTURERS INSTRUCTIONS.

6.) UNLESS NOTED OTHERWISE PROVIDE 3/4" CHAMFER ON ALL UNARMORED CORNERS.

7.) FIELD BEND REINFORCING BARS TO CLEAR INCIDENTAL BOXOUTS WHERE REQUIRED. EXCEPT AS NOTED, NO CUTTING OF REINFORCING BARS WITHOUT PRIOR REVIEW BY OWNER.

8.) VERTICAL CONCRETE SURFACES SHALL HAVE A SMOOTH FORMED FINISH. HORIZONTAL CONCRETE SURFACES SHALL HAVE A SMOOTH RUBBED FINISH (U.N.O.), EXCEPT WALKING SURFACE SHALL HAVE BROOM FINISH.

9.) CONCRETE SHALL BE CURED FOR A MINIMUM OF 7 DAYS IN ACCORDANCE WITH ACI 301.

10.) REPAIR ALL SURFACE VOIDS GREATER THAN 1/4" WITH METHOD APPROVAL BY ENGINEER

SEE SPECIFICATIONS SECTION 03310 FOR ADDITIONAL NOTES.

STEEL NOTES

1.) STEEL – ASTM A-36 U.N.O.
PIPE – A53 GRADE B
BOLTS – ASTM A-325 GALVANIZED

2.) ALL WELDING PER AWS D1-1.

3.) ALL STEEL HOT DIPPED GALVANIZED PER ASTM A-123, HARDWARE PER A-153 U.N.O.

4.) ALL STEEL SHALL BE FABRICATED AND ERECTED PER AISC STEEL CONSTRUCTION MANUAL 13th EDITION.

GENERAL GATE NOTES

SEE SPECIFICATIONS FOR SECTION 11281

KLEINSCHMIDT DRAWING LIST

DRAWING NO.	DRAWING DESCRIPTION
1	PLAN VIEW - POLISHING POND AND PROPOSED ACCESS TO GATE AND VAULT
2	LONGITUDINAL SECTION THRU POND AND ACCESS DETAILS
3	CONCRETE REINFORCEMENT SECTIONS AND DETAILS
4	STEEL FRAMING SECTIONS AND DETAILS

RECORD DRAWING

THIS DRAWING REPRESENTS THE BEST INFORMATION AVAILABLE TO THE ENGINEER UPON COMPLETION OF THE WORK.

KLEINSCHMIDT ASSOCIATES
CONSULTING ENGINEERS

DATE: 1/18/08 BY: TLK

SUBMIT SHOP DRAWINGS TO E.O.R FOR APPROVAL

No.	Revision	Date
	RECORD DRAWING	1-18-08
1	UPDATED VAULT AND GATE	10-22-07
	RELEASED FOR CONSTRUCTION	9-17-07

Scale: AS SHOWN
Project No: 112-059
AutoCad Release: 2007
Filename: 112-059 RD Sheet 1.dwg
Design By: KMG
Drawn By: HWF
Checked By: TLK
Date Revision: 1-18-08

CIANBRO CORPORATION
BALTIMORE, MARYLAND

BRUNNER ISLAND
POLISHING POND OUTLET MODIFICATIONS

PLAN VIEW - POLISHING POND AND PROPOSED ACCESS TO GATE AND VAULT

Kleinschmidt
Energy & Water Resource Consultants
P.O. Box 650 141 Main Street
Pittsfield, Maine 04967
Telephone: (207) 487-3328
Fax: (207) 487-3124
www.KleinschmidtUSA.com

THOMAS L. KAHL
PROFESSIONAL ENGINEER

1

REFERENCE TITLE	NUMBER	REFERENCE TITLE	NUMBER
WALKWAY AND STAIR ASSEMBLY AND DETAILS	E325756		
SITE PLAN	E158595		

BRUNNER ISLAND S.E.S.
POLISHING POND OUTLET MODIFICATIONS
PLAN VIEW - POLISHING POND AND PROPOSED ACCESS TO GATE AND VAULT

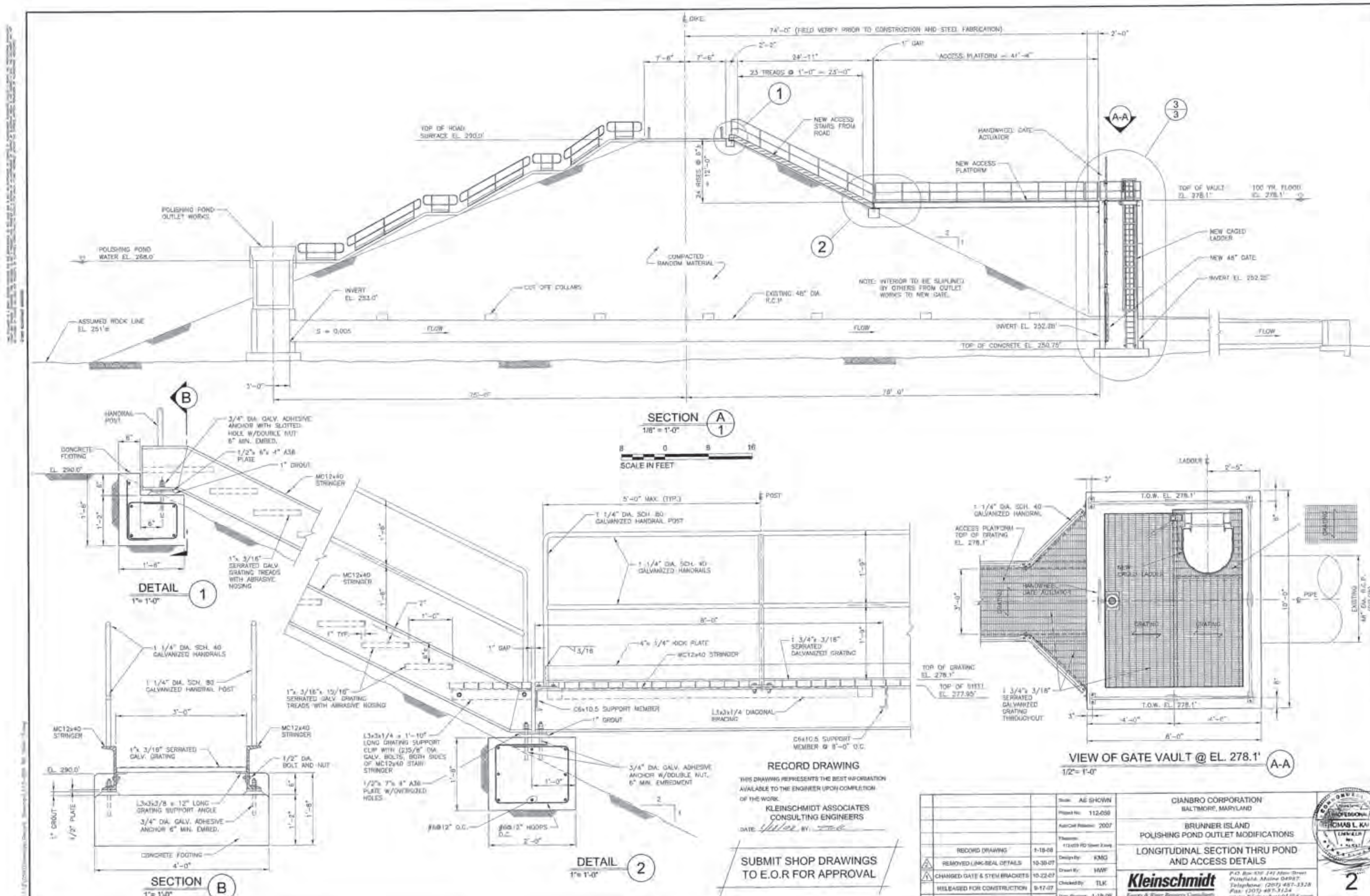
SCALE - AS SHOWN
BY OTHERS
D.D. HARPER

APPROVED: KLEINSCHMIDT DATE

PPL CORP.

PPL DRAWING NO. E325734
SHEET NO. 1
REV. 0

E325734_0.dwg



No.	Revision	Date
	RECORD DRAWING	1-18-08
2	REMOVED LINK-SEAL DETAILS	10-30-07
1	CHANGED GATE & STEM BRACKETS	10-22-07
	RELEASED FOR CONSTRUCTION	9-17-07

Scale: AS SHOWN
Project No: 112-059
AutoCad Release: 2007
Design By: KMG
Drawn By: HWF
Checked By: TLK
Date Revised: 1-18-08

CIANBRO CORPORATION
BALTIMORE, MARYLAND

BRUNNER ISLAND
POLISHING POND OUTLET MODIFICATIONS

LONGITUDINAL SECTION THRU POND
AND ACCESS DETAILS

Kleinschmidt
Energy & Water Resource Consultants

2

BRUNNER ISLAND S.E.S.

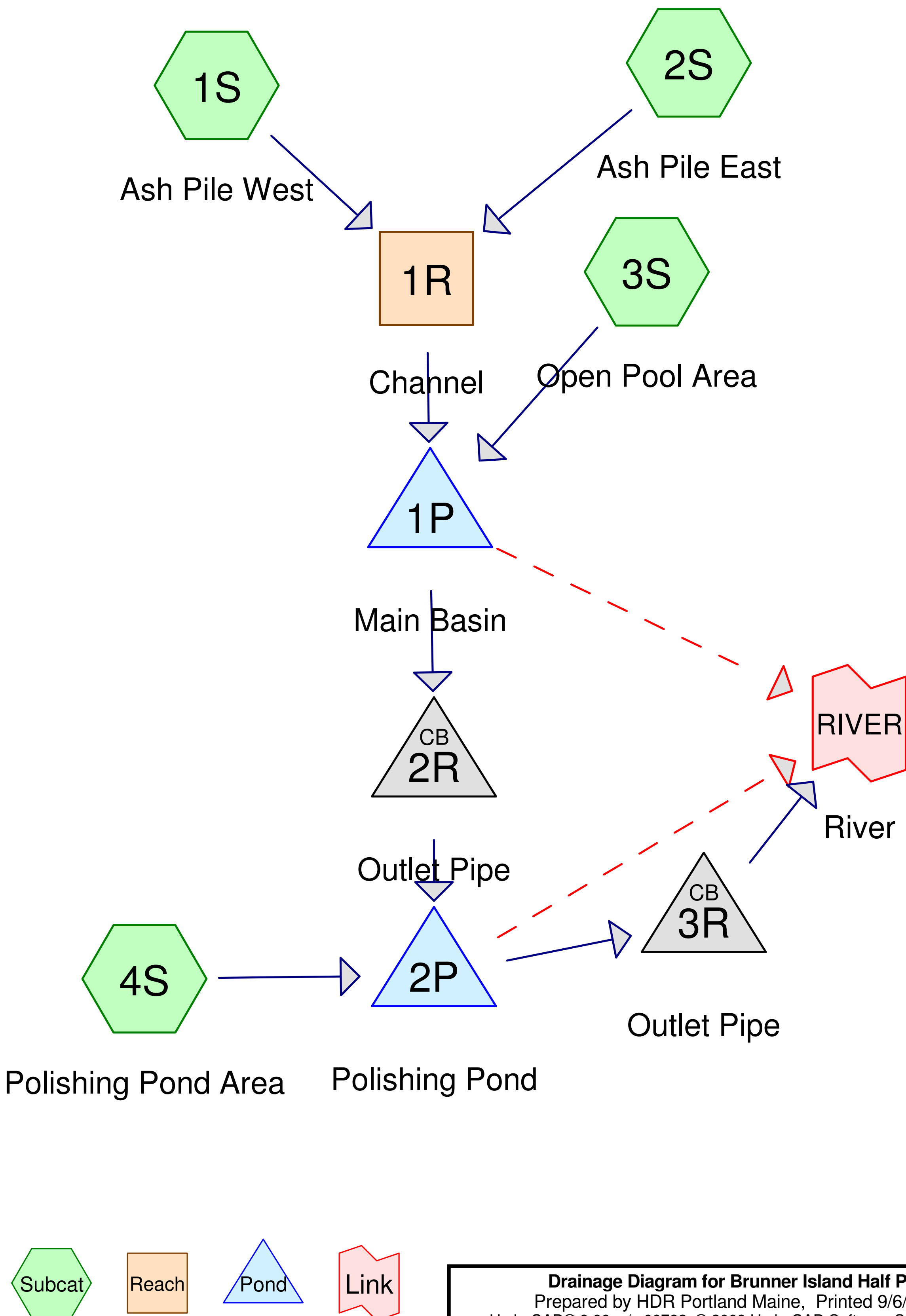
POLISHING POND OUTLET MODIFICATIONS
LONGITUDINAL SECTION THRU POND
AND ACCESS DETAILS

PPL CORP.

E325734
SHEET NO. 2
REV. 0

APPENDIX B

HYDROCAD ANALYSIS REPORT & WAVE RUN UP CALCULATION



Drainage Diagram for Brunner Island Half PMP
Prepared by HDR Portland Maine, Printed 9/6/2012
HydroCAD® 9.00 s/n 00782 © 2009 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
12.315	80	Active Area (1S)
49.524	88	Non Active Area (1S, 2S, 3S, 4S)
14.601	98	Open Water (3S, 4S)
76.440		**TOTAL AREA**

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)
1	2R	271.00	270.75	122.0	0.0020	0.015	48.0	0.0
2	3R	253.00	252.00	205.0	0.0049	0.015	48.0	0.0

Time span=0.00-36.00 hrs, dt=0.01 hrs, 3601 points x 2
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Muskingum-Cunge method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Ash Pile West Runoff Area=40.920 ac 0.00% Impervious Runoff Depth=17.40"
Flow Length=2,566' Tc=17.5 min CN=86 Runoff=265.22 cfs 59.319 af

Subcatchment 2S: Ash Pile East Runoff Area=15.550 ac 0.00% Impervious Runoff Depth=17.68"
Flow Length=1,887' Tc=15.6 min CN=88 Runoff=108.16 cfs 22.904 af

Subcatchment 3S: Open Pool Area Runoff Area=17.260 ac 73.64% Impervious Runoff Depth=18.60"
Flow Length=1,262' Slope=0.0167 '/' Tc=8.3 min CN=95 Runoff=150.80 cfs 26.757 af

Subcatchment 4S: Polishing Pond Area Runoff Area=2.710 ac 69.78% Impervious Runoff Depth=18.60"
Flow Length=401' Tc=2.6 min CN=95 Runoff=25.32 cfs 4.201 af

Reach 1R: Channel Avg. Depth=2.17' Max Vel=6.30 fps Inflow=372.24 cfs 82.223 af
n=0.025 L=313.0' S=0.0010 '/' Capacity=675.96 cfs Outflow=371.66 cfs 82.223 af

Pond 1P: Main Basin Peak Elev=288.42' Storage=178.535 af Inflow=491.93 cfs 108.980 af
Primary=112.92 cfs 109.854 af Secondary=0.00 cfs 0.000 af Outflow=112.92 cfs 109.854 af

Pond 2P: Polishing Pond Peak Elev=285.58' Storage=1,053,313 cf Inflow=117.10 cfs 114.055 af
Primary=100.96 cfs 105.608 af Secondary=0.00 cfs 0.000 af Outflow=100.96 cfs 105.582 af

Pond 2R: Outlet Pipe Peak Elev=288.63' Inflow=112.92 cfs 109.854 af
48.0" Round Culvert n=0.015 L=122.0' S=0.0020 '/' Outflow=112.92 cfs 109.854 af

Pond 3R: Outlet Pipe Peak Elev=281.06' Inflow=100.96 cfs 105.608 af
48.0" Round Culvert n=0.015 L=205.0' S=0.0049 '/' Outflow=100.96 cfs 105.608 af

Link RIVER: River Inflow=100.96 cfs 105.608 af
Primary=100.96 cfs 105.608 af

Total Runoff Area = 76.440 ac Runoff Volume = 113.181 af Average Runoff Depth = 17.77"
80.90% Pervious = 61.839 ac 19.10% Impervious = 14.601 ac

Summary for Subcatchment 1S: Ash Pile West

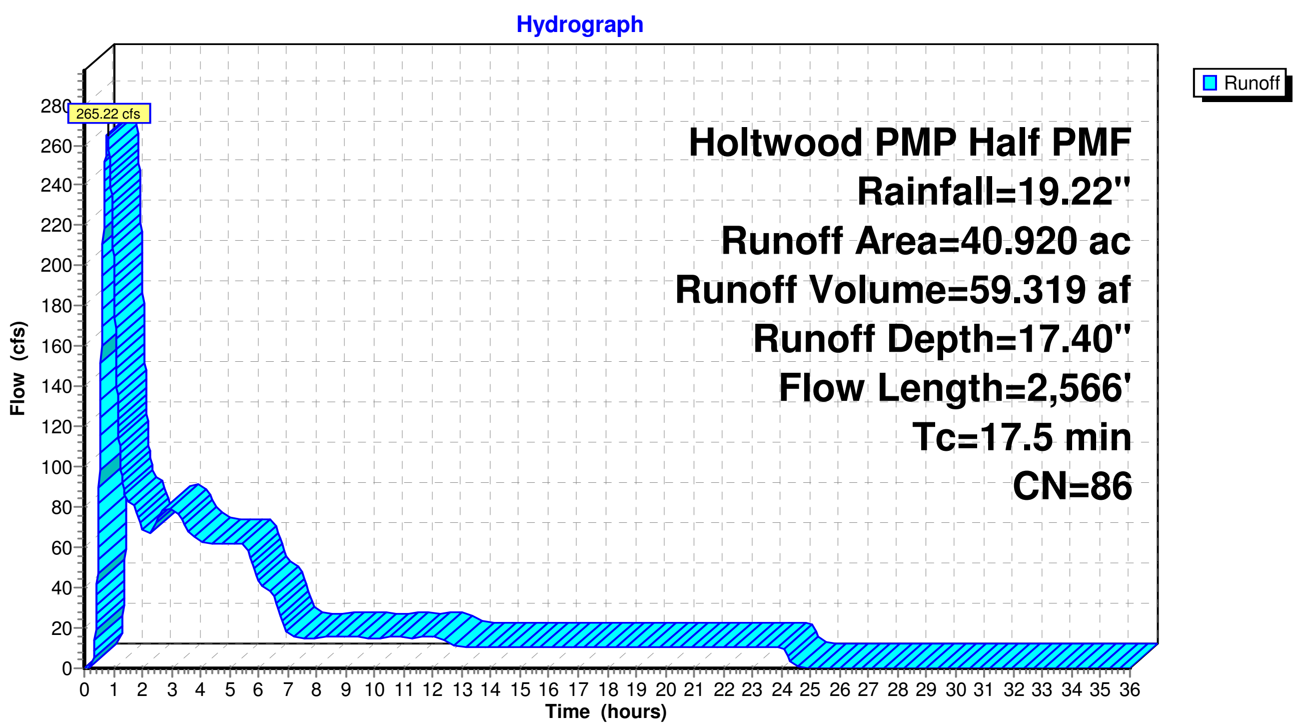
Runoff = 265.22 cfs @ 0.80 hrs, Volume= 59.319 af, Depth=17.40"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Holtwood PMP Half PMF Rainfall=19.22"

	Area (ac)	CN	Description
*	28.605	88	Non Active Area
*	12.315	80	Active Area
	40.920	86	Weighted Average
	40.920		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.3	50	0.0200	0.36		**Sheet Flow, Sheet Flow** Fallow n= 0.050 P2= 3.20"
4.6	428	0.0240	1.55		**Shallow Concentrated Flow, Overland Flow** Nearly Bare & Untilled Kv= 10.0 fps
10.6	2,088	0.0010	3.27	176.82	**Trap/Vee/Rect Channel Flow, Channel** Bot.W=15.00' D=3.00' Z= 1.0 '/' Top.W=21.00' n= 0.025
17.5	2,566	Total			

Subcatchment 1S: Ash Pile West



Hydrograph for Subcatchment 1S: Ash Pile West

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
0.50	2.57	1.30	**82.13**
1.00	5.29	3.74	**204.32**
1.50	6.32	4.71	83.00
2.00	7.20	5.56	69.87
2.50	8.12	6.45	73.45
3.00	9.11	7.41	79.40
3.50	9.97	8.26	70.09
4.00	10.75	9.02	62.79
4.50	11.51	9.77	62.01
5.00	12.28	10.52	62.23
5.50	13.02	11.25	61.23
6.00	13.55	11.77	43.03
6.50	13.98	12.20	36.66
7.00	14.20	12.42	17.58
7.50	14.39	12.60	15.11
8.00	14.57	12.78	15.15
8.50	14.76	12.97	15.41
9.00	14.95	13.16	15.21
9.50	15.13	13.34	15.39
10.00	15.32	13.52	15.09
10.50	15.50	13.71	15.23
11.00	15.69	13.90	15.35
11.50	15.88	14.08	15.29
12.00	16.07	14.27	15.34
12.50	16.22	14.42	12.93
13.00	16.35	14.55	10.71
13.50	16.48	14.68	10.66
14.00	16.61	14.81	10.66
14.50	16.74	14.94	10.66
15.00	16.87	15.07	10.67
15.50	17.01	15.20	10.67
16.00	17.14	15.33	10.67
16.50	17.27	15.45	10.67
17.00	17.40	15.58	10.67
17.50	17.53	15.71	10.66
18.00	17.66	15.84	10.67
18.50	17.79	15.97	10.67
19.00	17.92	16.10	10.68
19.50	18.05	16.23	10.68
20.00	18.18	16.36	10.68
20.50	18.31	16.49	10.67
21.00	18.44	16.62	10.67
21.50	18.57	16.75	10.68
22.00	18.70	16.88	10.68
22.50	18.83	17.01	10.69
23.00	18.96	17.14	10.69
23.50	19.09	17.27	10.68
24.00	**19.22**	**17.40**	10.68
24.50	19.22	17.40	0.64
25.00	19.22	17.40	0.00
25.50	19.22	17.40	0.00
26.00	19.22	17.40	0.00
26.50	19.22	17.40	0.00
27.00	19.22	17.40	0.00
27.50	19.22	17.40	0.00
28.00	19.22	17.40	0.00
28.50	19.22	17.40	0.00
29.00	19.22	17.40	0.00
29.50	19.22	17.40	0.00
30.00	19.22	17.40	0.00
30.50	19.22	17.40	0.00
31.00	19.22	17.40	0.00
31.50	19.22	17.40	0.00
32.00	19.22	17.40	0.00
32.50	19.22	17.40	0.00
33.00	19.22	17.40	0.00
33.50	19.22	17.40	0.00
34.00	19.22	17.40	0.00
34.50	19.22	17.40	0.00
35.00	19.22	17.40	0.00
35.50	19.22	17.40	0.00
36.00	19.22	17.40	0.00

Summary for Subcatchment 2S: Ash Pile East

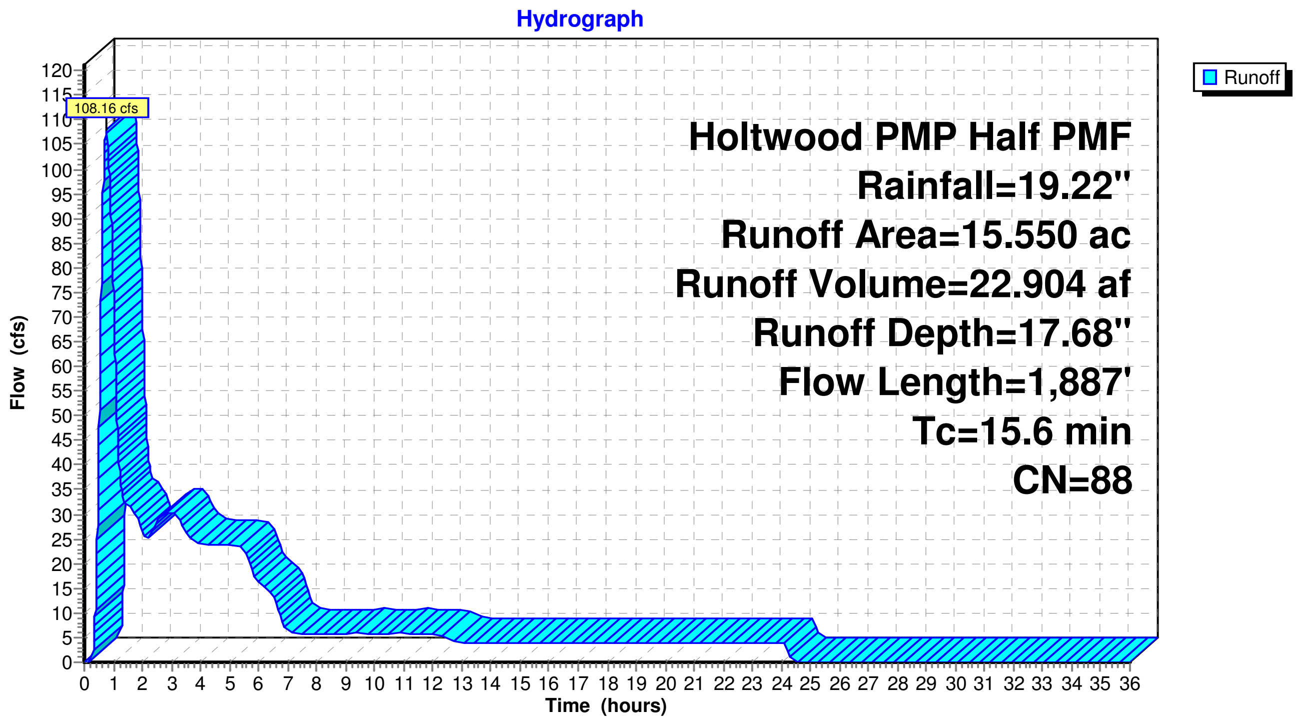
Runoff = 108.16 cfs @ 0.75 hrs, Volume= 22.904 af, Depth=17.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Holtwood PMP Half PMF Rainfall=19.22"

	Area (ac)	CN	Description
*	15.550	88	Non Active Area
	15.550		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.3	50	0.0200	0.36		**Sheet Flow, Sheet Flow** Fallow n= 0.050 P2= 3.20"
3.4	353	0.0300	1.73		**Shallow Concentrated Flow, Overland Flow** Nearly Bare & Untilled Kv= 10.0 fps
9.9	1,484	0.0010	2.50	59.97	**Trap/Vee/Rect Channel Flow, Channel Flow** Bot.W=10.00' D=2.00' Z= 1.0 '/' Top.W=14.00' n= 0.025
15.6	1,887	Total			

Subcatchment 2S: Ash Pile East



Hydrograph for Subcatchment 2S: Ash Pile East

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
0.50	2.57	1.44	**44.01**
1.00	5.29	3.95	**75.04**
1.50	6.32	4.93	31.57
2.00	7.20	5.79	26.37
2.50	8.12	6.69	28.52
3.00	9.11	7.65	30.43
3.50	9.97	8.51	26.52
4.00	10.75	9.27	23.90
4.50	11.51	10.03	23.68
5.00	12.28	10.78	23.74
5.50	13.02	11.51	23.21
6.00	13.55	12.04	16.05
6.50	13.98	12.47	13.74
7.00	14.20	12.69	6.43
7.50	14.39	12.87	5.75
8.00	14.57	13.05	5.78
8.50	14.76	13.24	5.87
9.00	14.95	13.43	5.80
9.50	15.13	13.61	5.86
10.00	15.32	13.80	5.75
10.50	15.50	13.98	5.81
11.00	15.69	14.17	5.85
11.50	15.88	14.35	5.83
12.00	16.07	14.54	5.83
12.50	16.22	14.69	4.83
13.00	16.35	14.82	4.07
13.50	16.48	14.95	4.06
14.00	16.61	15.08	4.06
14.50	16.74	15.21	4.06
15.00	16.87	15.34	4.06
15.50	17.01	15.47	4.06
16.00	17.14	15.60	4.06
16.50	17.27	15.73	4.06
17.00	17.40	15.86	4.07
17.50	17.53	15.99	4.06
18.00	17.66	16.12	4.06
18.50	17.79	16.25	4.07
19.00	17.92	16.38	4.06
19.50	18.05	16.51	4.07
20.00	18.18	16.64	4.06
20.50	18.31	16.77	4.07
21.00	18.44	16.90	4.07
21.50	18.57	17.03	4.07
22.00	18.70	17.16	4.07
22.50	18.83	17.29	4.06
23.00	18.96	17.42	4.07
23.50	19.09	17.55	4.07
24.00	**19.22**	**17.68**	4.07
24.50	19.22	17.68	0.14
25.00	19.22	17.68	0.00
25.50	19.22	17.68	0.00
26.00	19.22	17.68	0.00
26.50	19.22	17.68	0.00
27.00	19.22	17.68	0.00
27.50	19.22	17.68	0.00
28.00	19.22	17.68	0.00
28.50	19.22	17.68	0.00
29.00	19.22	17.68	0.00
29.50	19.22	17.68	0.00
30.00	19.22	17.68	0.00
30.50	19.22	17.68	0.00
31.00	19.22	17.68	0.00
31.50	19.22	17.68	0.00
32.00	19.22	17.68	0.00
32.50	19.22	17.68	0.00
33.00	19.22	17.68	0.00
33.50	19.22	17.68	0.00
34.00	19.22	17.68	0.00
34.50	19.22	17.68	0.00
35.00	19.22	17.68	0.00
35.50	19.22	17.68	0.00
36.00	19.22	17.68	0.00

Summary for Subcatchment 3S: Open Pool Area

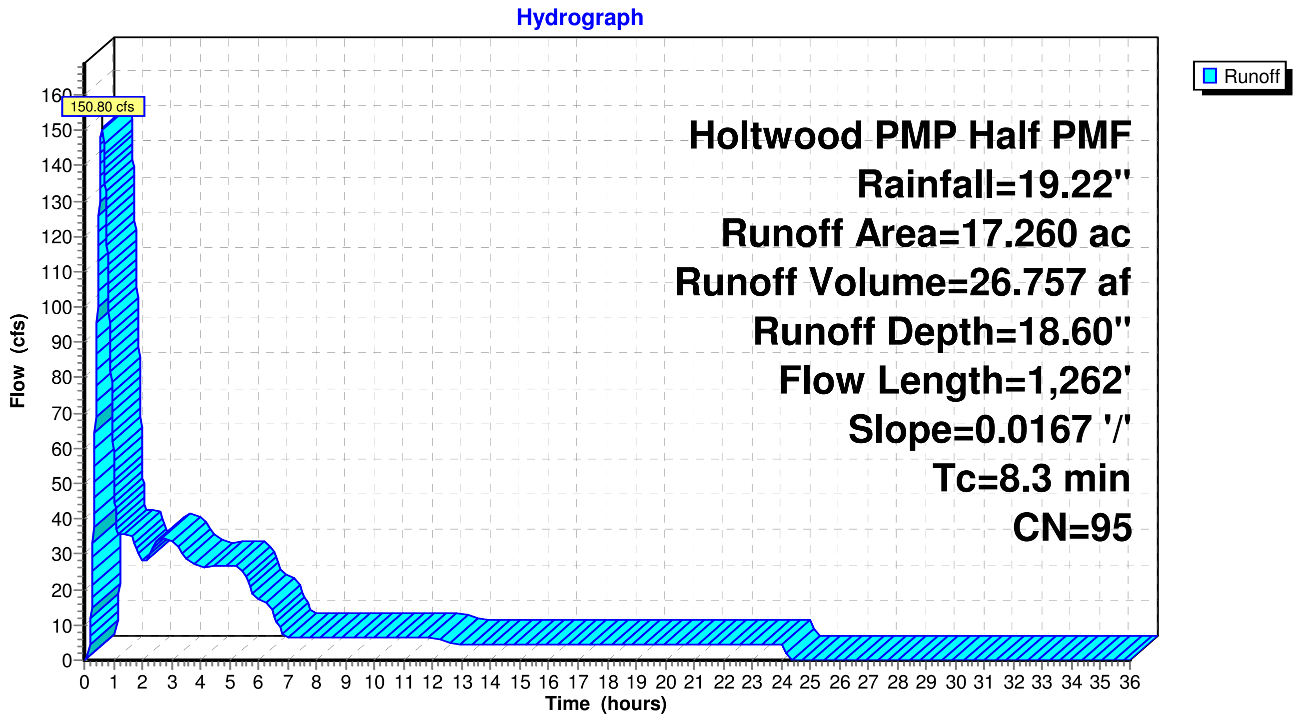
Runoff = 150.80 cfs @ 0.62 hrs, Volume= 26.757 af, Depth=18.60"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Holtwood PMP Half PMF Rainfall=19.22"

	Area (ac)	CN	Description
*	12.710	98	Open Water
*	4.550	88	Non Active Area
	17.260	95	Weighted Average
	4.550		26.36% Pervious Area
	12.710		73.64% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.5	50	0.0167	0.33		**Sheet Flow, Sheet Flow** Fallow n= 0.050 P2= 3.20"
5.1	394	0.0167	1.29		**Shallow Concentrated Flow, Shallow Flow** Nearly Bare & Untilled Kv= 10.0 fps
0.7	818		20.46		**Lake or Reservoir, Through Pond** Mean Depth= 13.00'
8.3	1,262	Total			

Subcatchment 3S: Open Pool Area



Hydrograph for Subcatchment 3S: Open Pool Area

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
0.50	2.57	2.03	**121.52**
1.00	5.29	4.71	**59.00**
1.50	6.32	5.73	36.20
2.00	7.20	6.60	27.86
2.50	8.12	7.52	34.01
3.00	9.11	8.50	34.09
3.50	9.97	9.37	28.72
4.00	10.75	10.14	26.47
4.50	11.51	10.91	26.58
5.00	12.28	11.67	26.59
5.50	13.02	12.41	24.71
6.00	13.55	12.94	17.05
6.50	13.98	13.37	13.69
7.00	14.20	13.59	6.57
7.50	14.39	13.77	6.42
8.00	14.57	13.96	6.49
8.50	14.76	14.15	6.52
9.00	14.95	14.33	6.51
9.50	15.13	14.52	6.50
10.00	15.32	14.70	6.42
10.50	15.50	14.89	6.53
11.00	15.69	15.08	6.49
11.50	15.88	15.27	6.55
12.00	16.07	15.45	6.47
12.50	16.22	15.61	4.96
13.00	16.35	15.74	4.53
13.50	16.48	15.87	4.53
14.00	16.61	16.00	4.53
14.50	16.74	16.13	4.53
15.00	16.87	16.26	4.53
15.50	17.01	16.39	4.53
16.00	17.14	16.52	4.53
16.50	17.27	16.65	4.53
17.00	17.40	16.78	4.53
17.50	17.53	16.91	4.53
18.00	17.66	17.04	4.53
18.50	17.79	17.17	4.53
19.00	17.92	17.30	4.53
19.50	18.05	17.43	4.53
20.00	18.18	17.56	4.53
20.50	18.31	17.69	4.53
21.00	18.44	17.82	4.53
21.50	18.57	17.95	4.53
22.00	18.70	18.08	4.53
22.50	18.83	18.21	4.53
23.00	18.96	18.34	4.53
23.50	19.09	18.47	4.53
24.00	**19.22**	**18.60**	4.53
24.50	19.22	18.60	0.00
25.00	19.22	18.60	0.00
25.50	19.22	18.60	0.00

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
26.00	19.22	18.60	0.00
26.50	19.22	18.60	0.00
27.00	19.22	18.60	0.00
27.50	19.22	18.60	0.00
28.00	19.22	18.60	0.00
28.50	19.22	18.60	0.00
29.00	19.22	18.60	0.00
29.50	19.22	18.60	0.00
30.00	19.22	18.60	0.00
30.50	19.22	18.60	0.00
31.00	19.22	18.60	0.00
31.50	19.22	18.60	0.00
32.00	19.22	18.60	0.00
32.50	19.22	18.60	0.00
33.00	19.22	18.60	0.00
33.50	19.22	18.60	0.00
34.00	19.22	18.60	0.00
34.50	19.22	18.60	0.00
35.00	19.22	18.60	0.00
35.50	19.22	18.60	0.00
36.00	19.22	18.60	0.00

Summary for Subcatchment 4S: Polishing Pond Area

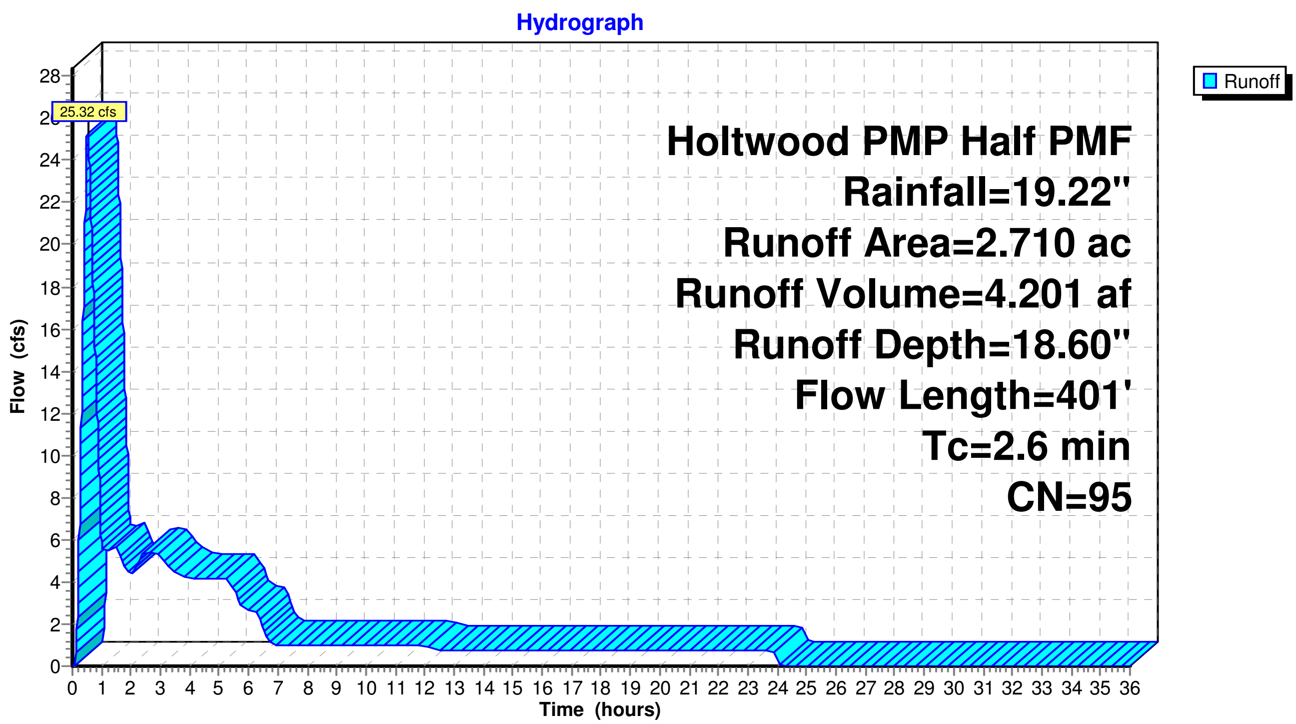
Runoff = 25.32 cfs @ 0.52 hrs, Volume= 4.201 af, Depth=18.60"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Holtwood PMP Half PMF Rainfall=19.22"

	Area (ac)	CN	Description
*	1.891	98	Open Water
*	0.819	88	Non Active Area
	2.710	95	Weighted Average
	0.819		30.22% Pervious Area
	1.891		69.78% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.3	50	0.0200	0.36		**Sheet Flow, Shallow Flow** Fallow n= 0.050 P2= 3.20"
0.2	129	0.0620	11.75	46.99	**Trap/Vee/Rect Channel Flow, Swale** Bot.W=0.00' D=2.00' Z= 1.0 '/' Top.W=4.00' n= 0.025
0.1	222		28.93		**Lake or Reservoir, Flow through pond** Mean Depth= 26.00'
2.6	401	Total			

Subcatchment 4S: Polishing Pond Area



Hydrograph for Subcatchment 4S: Polishing Pond Area

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
0.50	2.57	2.03	**24.74**
1.00	5.29	4.71	**5.66**
1.50	6.32	5.73	5.67
2.00	7.20	6.60	4.30
2.50	8.12	7.52	5.43
3.00	9.11	8.50	5.24
3.50	9.97	9.37	4.42
4.00	10.75	10.14	4.15
4.50	11.51	10.91	4.18
5.00	12.28	11.67	4.18
5.50	13.02	12.41	3.62
6.00	13.55	12.94	2.65
6.50	13.98	13.37	1.87
7.00	14.20	13.59	1.02
7.50	14.39	13.77	1.01
8.00	14.57	13.96	1.02
8.50	14.76	14.15	1.02
9.00	14.95	14.33	1.03
9.50	15.13	14.52	1.02
10.00	15.32	14.70	1.01
10.50	15.50	14.89	1.03
11.00	15.69	15.08	1.01
11.50	15.88	15.27	1.03
12.00	16.07	15.45	1.01
12.50	16.22	15.61	0.72
13.00	16.35	15.74	0.71
13.50	16.48	15.87	0.71
14.00	16.61	16.00	0.71
14.50	16.74	16.13	0.71
15.00	16.87	16.26	0.71
15.50	17.01	16.39	0.71
16.00	17.14	16.52	0.71
16.50	17.27	16.65	0.71
17.00	17.40	16.78	0.71
17.50	17.53	16.91	0.71
18.00	17.66	17.04	0.71
18.50	17.79	17.17	0.71
19.00	17.92	17.30	0.71
19.50	18.05	17.43	0.71
20.00	18.18	17.56	0.71
20.50	18.31	17.69	0.71
21.00	18.44	17.82	0.71
21.50	18.57	17.95	0.71
22.00	18.70	18.08	0.71
22.50	18.83	18.21	0.71
23.00	18.96	18.34	0.71
23.50	19.09	18.47	0.71
24.00	**19.22**	**18.60**	0.71
24.50	19.22	18.60	0.00
25.00	19.22	18.60	0.00
25.50	19.22	18.60	0.00
26.00	19.22	18.60	0.00
26.50	19.22	18.60	0.00
27.00	19.22	18.60	0.00
27.50	19.22	18.60	0.00
28.00	19.22	18.60	0.00
28.50	19.22	18.60	0.00
29.00	19.22	18.60	0.00
29.50	19.22	18.60	0.00
30.00	19.22	18.60	0.00
30.50	19.22	18.60	0.00
31.00	19.22	18.60	0.00
31.50	19.22	18.60	0.00
32.00	19.22	18.60	0.00
32.50	19.22	18.60	0.00
33.00	19.22	18.60	0.00
33.50	19.22	18.60	0.00
34.00	19.22	18.60	0.00
34.50	19.22	18.60	0.00
35.00	19.22	18.60	0.00
35.50	19.22	18.60	0.00
36.00	19.22	18.60	0.00

Summary for Reach 1R: Channel

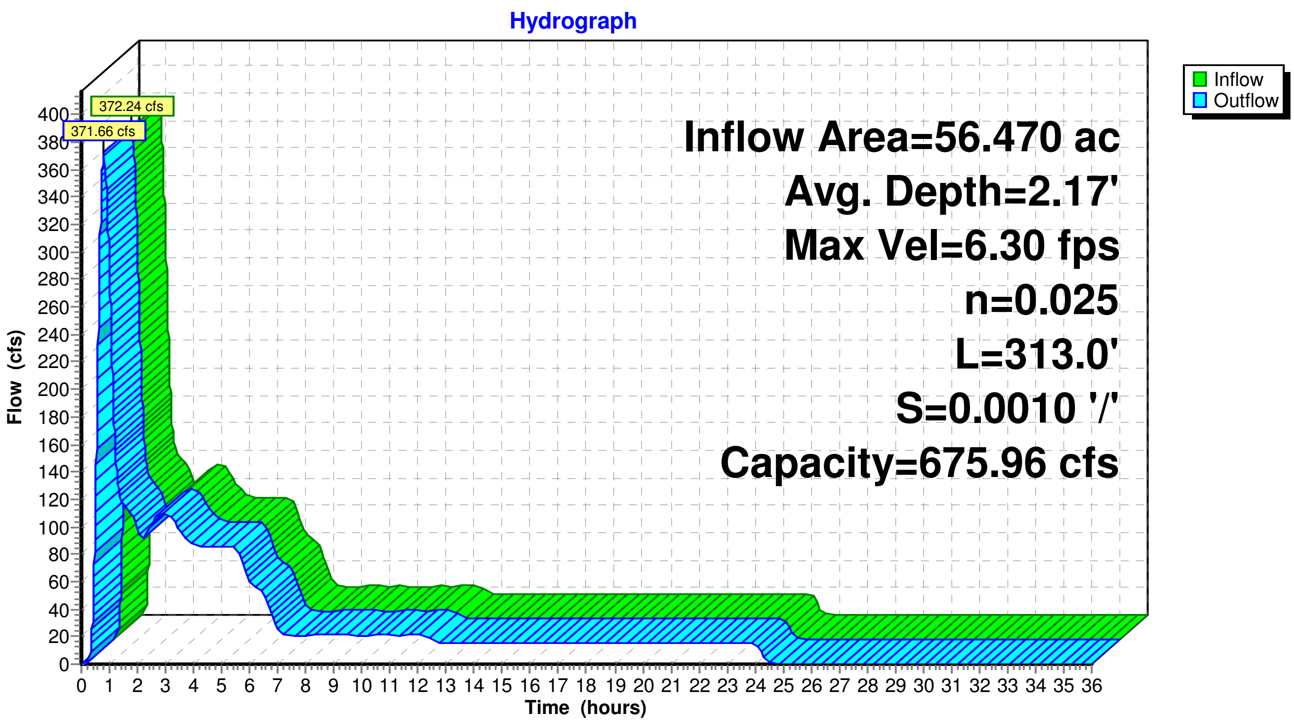
Inflow Area = 56.470 ac, 0.00% Impervious, Inflow Depth = 17.47" for Half PMF event
Inflow = 372.24 cfs @ 0.78 hrs, Volume= 82.223 af
Outflow = 371.66 cfs @ 0.80 hrs, Volume= 82.223 af, Atten= 0%, Lag= 0.9 min

Routing by Dyn-Muskingum-Cunge method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs / 2
Reference Flow= 506.97 cfs Estimated Depth= 4.22' Velocity= 4.11 fps
m= 1.532, c= 6.30 fps, dt= 0.6 min, dx= 313.0' / 1 = 313.0', K= 0.8 min, X= 0.000
Max. Velocity= 6.30 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 6.30 fps, Avg. Travel Time= 0.8 min

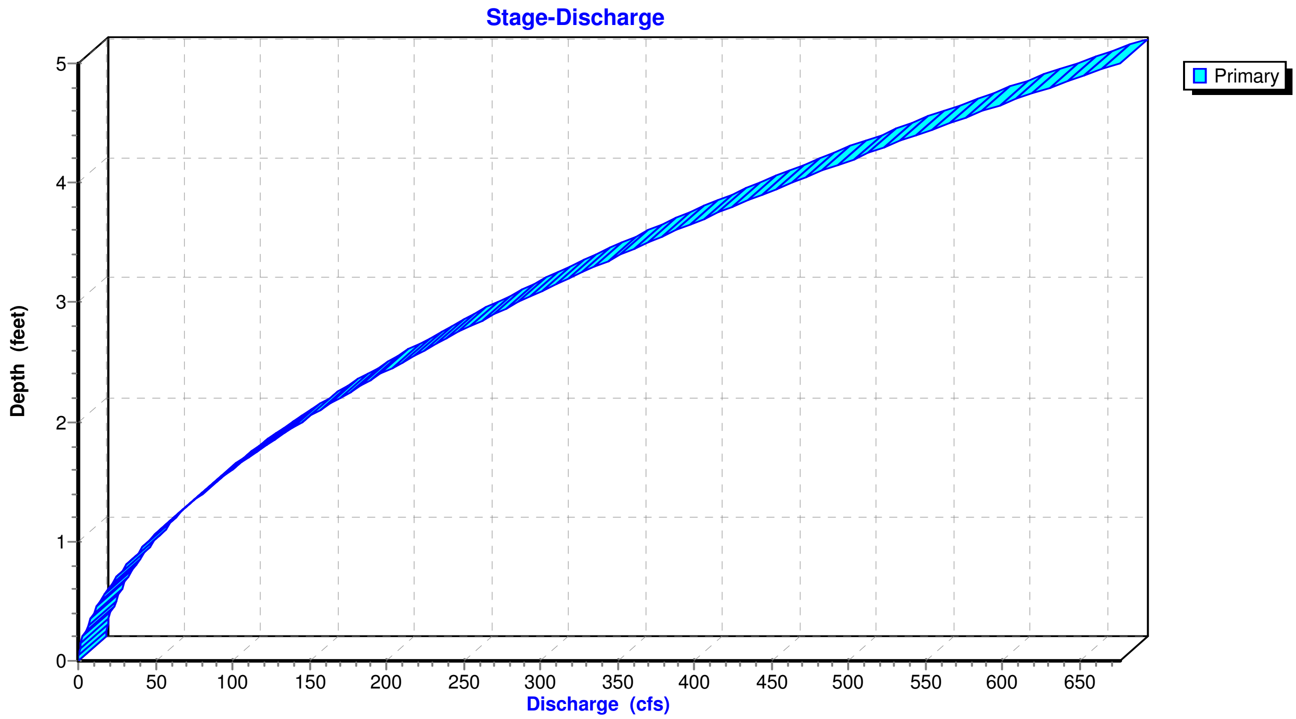
Peak Storage= 18,471 cf @ 0.80 hrs, Average Depth at Peak Storage= 2.17'
Bank-Full Depth= 5.00', Capacity at Bank-Full= 675.96 cfs

25.00' x 5.00' deep channel, n= 0.025
Side Slope Z-value= 1.0 '/' Top Width= 35.00'
Length= 313.0' Slope= 0.0010 '/'
Inlet Invert= 286.30', Outlet Invert= 286.00'

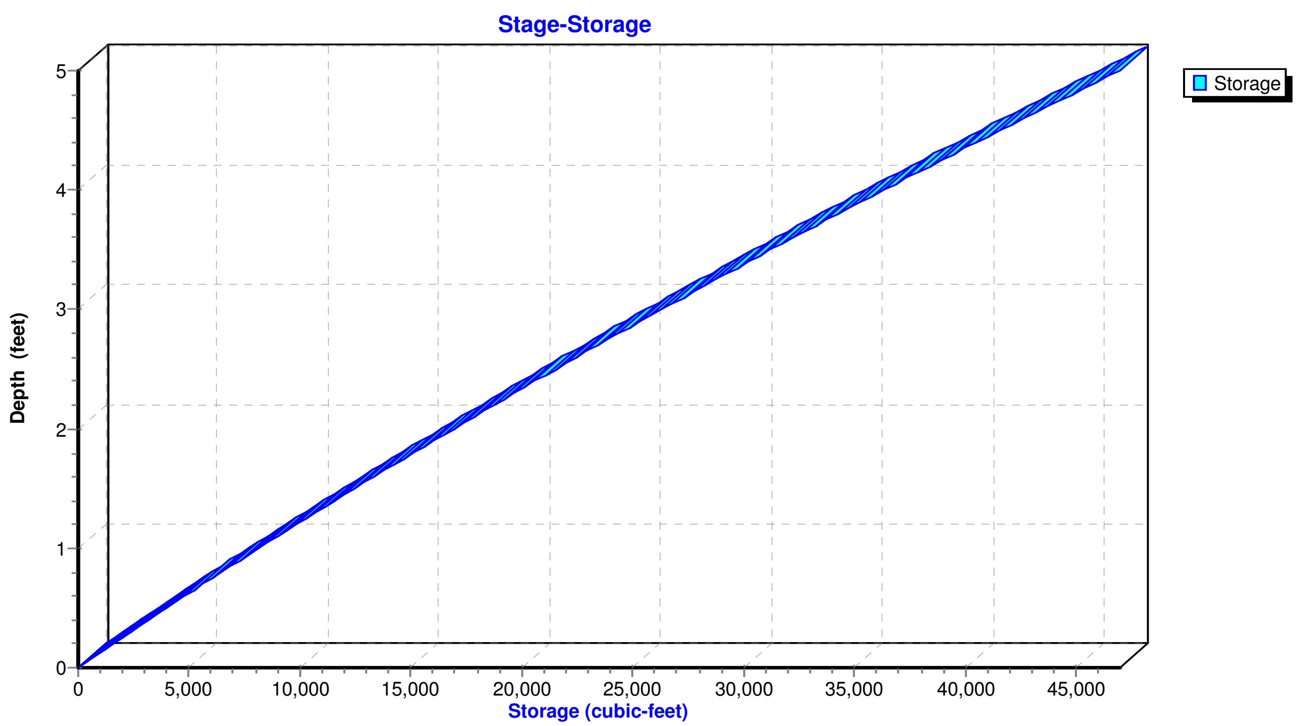
Reach 1R: Channel



Reach 1R: Channel



Reach 1R: Channel



Hydrograph for Reach 1R: Channel

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)
0.00	**0.00**	**0**	**286.30**	**0.00**
1.00	**279.36**	**14,349**	**288.02**	**288.73**
2.00	96.24	4,822	286.90	97.02
3.00	109.83	5,460	286.98	109.86
4.00	86.68	4,318	286.84	86.88
5.00	85.97	4,271	286.83	85.94
6.00	59.08	2,961	286.67	59.58
7.00	24.01	1,213	286.45	24.41
8.00	20.92	1,039	286.43	20.91
9.00	21.01	1,043	286.43	20.99
10.00	20.85	1,036	286.43	20.85
11.00	21.20	1,054	286.43	21.22
12.00	21.17	1,053	286.43	21.18
13.00	14.78	735	286.39	14.79
14.00	14.72	732	286.39	14.72
15.00	14.73	732	286.39	14.73
16.00	14.74	732	286.39	14.73
17.00	14.73	732	286.39	14.73
18.00	14.73	732	286.39	14.74
19.00	14.74	733	286.39	14.74
20.00	14.74	733	286.39	14.74
21.00	14.74	733	286.39	14.74
22.00	14.75	733	286.39	14.75
23.00	14.76	733	286.39	14.75
24.00	14.75	733	286.39	14.75
25.00	0.00	0	286.30	0.00
26.00	0.00	0	286.30	0.00
27.00	0.00	0	286.30	0.00
28.00	0.00	0	286.30	0.00
29.00	0.00	0	286.30	0.00
30.00	0.00	0	286.30	0.00
31.00	0.00	0	286.30	0.00
32.00	0.00	0	286.30	0.00
33.00	0.00	0	286.30	0.00
34.00	0.00	0	286.30	0.00
35.00	0.00	0	286.30	0.00
36.00	0.00	0	286.30	0.00

Stage-Discharge for Reach 1R: Channel

Elevation (feet)	Velocity (ft/sec)	Discharge (cfs)	m-Value	Celerity (ft/sec)
286.30	0.00	0.00	**1.661**	0.00
286.35	0.25	0.31	1.661	0.41
286.40	0.39	0.99	1.661	0.66
286.45	0.52	1.95	1.659	0.86
286.50	0.62	3.14	1.657	1.03
286.55	0.72	4.56	1.655	1.19
286.60	0.81	6.17	1.653	1.34
286.65	0.90	7.98	1.651	1.48
286.70	0.98	9.96	1.649	1.62
286.75	1.06	12.12	1.647	1.74
286.80	1.13	14.44	1.644	1.86
286.85	1.20	16.92	1.642	1.98
286.90	1.27	19.55	1.640	2.09
286.95	1.34	22.34	1.638	2.19
287.00	1.40	25.27	1.636	2.30
287.05	1.47	28.34	1.634	2.40
287.10	1.53	31.55	1.632	2.49
287.15	1.59	34.90	1.630	2.59
287.20	1.65	38.38	1.628	2.68
287.25	1.70	41.99	1.626	2.77
287.30	1.76	45.73	1.624	2.86
287.35	1.81	49.59	1.622	2.94
287.40	1.87	53.58	1.621	3.02
287.45	1.92	57.69	1.619	3.11
287.50	1.97	61.92	1.617	3.18
287.55	2.02	66.27	1.615	3.26
287.60	2.07	70.74	1.613	3.34
287.65	2.12	75.33	1.611	3.41
287.70	2.17	80.02	1.610	3.49
287.75	2.21	84.84	1.608	3.56
287.80	2.26	89.76	1.606	3.63
287.85	2.30	94.80	1.604	3.70
287.90	2.35	99.94	1.603	3.76
287.95	2.39	105.19	1.601	3.83
288.00	2.44	110.55	1.599	3.90
288.05	2.48	116.02	1.598	3.96
288.10	2.52	121.60	1.596	4.02
288.15	2.56	127.28	1.595	4.09
288.20	2.60	133.06	1.593	4.15
288.25	2.64	138.95	1.591	4.21
288.30	2.68	144.93	1.590	4.27
288.35	2.72	151.03	1.588	4.33
288.40	2.76	157.22	1.587	4.38
288.45	2.80	163.51	1.585	4.44
288.50	2.84	169.91	1.584	4.50
288.55	2.88	176.40	1.582	4.55
288.60	2.91	182.99	1.581	4.61
288.65	2.95	189.68	1.579	4.66
288.70	2.99	196.47	1.578	4.71
288.75	3.02	203.35	1.576	4.77
288.80	3.06	210.34	1.575	4.82
288.85	3.09	217.41	1.573	4.87
288.90	3.13	224.59	1.572	4.92
288.95	3.16	231.86	1.571	4.97
289.00	3.20	239.22	1.569	5.02
289.05	3.23	246.68	1.568	5.07
289.10	3.27	254.24	1.566	5.12
289.15	3.30	261.88	1.565	5.16
289.20	3.33	269.62	1.564	5.21
289.25	3.37	277.46	1.562	5.26
289.30	3.40	285.38	1.561	5.30
289.35	3.43	293.40	1.560	5.35
289.40	3.46	301.52	1.558	5.39
289.45	3.49	309.72	1.557	5.44
289.50	3.52	318.01	1.556	5.48
289.55	3.56	326.40	1.555	5.53
289.60	3.59	334.88	1.553	5.57
289.65	3.62	343.45	1.552	5.61
289.70	3.65	352.11	1.551	5.66
289.75	3.68	360.85	1.550	5.70
289.80	3.71	369.69	1.548	5.74
289.85	3.74	378.62	1.547	5.78
289.90	3.76	387.64	1.546	5.82
289.95	3.79	396.75	1.545	5.86
290.00	3.82	405.95	1.544	5.90
290.05	3.85	415.24	1.543	5.94
290.10	3.88	424.61	1.541	5.98
290.15	3.91	434.08	1.540	6.02
290.20	3.94	443.63	1.539	6.06
290.25	3.96	453.27	1.538	6.10
290.30	3.99	463.00	1.537	6.13
290.35	4.02	472.82	1.536	6.17
290.40	4.05	482.73	1.535	6.21
290.45	4.07	492.72	1.534	6.25
290.50	4.10	502.80	1.533	6.28
290.55	4.13	512.97	1.531	6.32
290.60	4.15	523.23	1.530	6.36
290.65	4.18	533.57	1.529	6.39
290.70	4.21	544.01	1.528	6.43
290.75	4.23	554.53	1.527	6.46
290.80	4.26	565.13	1.526	6.50
290.85	4.28	575.82	1.525	6.53
290.90	4.31	586.60	1.524	6.57
290.95	4.33	597.47	1.523	6.60
291.00	4.36	608.42	1.522	6.63
291.05	4.38	619.46	1.521	6.67
291.10	4.41	630.59	1.520	6.70
291.15	4.43	641.80	1.519	6.73
291.20	4.46	653.10	1.518	6.77
291.25	4.48	664.49	1.517	6.80
291.30	**4.51**	**675.96**	1.516	**6.83**

Stage-Area-Storage for Reach 1R: Channel

Elevation (feet)	End-Area (sq-ft)	Storage (cubic-feet)	Elevation (feet)	End-Area (sq-ft)	Storage (cubic-feet)
286.30	0.0	0	288.90	71.8	22,461
286.35	1.3	392	288.95	73.3	22,934
286.40	2.5	786	289.00	74.8	23,409
286.45	3.8	1,181	289.05	76.3	23,886
286.50	5.0	1,578	289.10	77.8	24,364
286.55	6.3	1,976	289.15	79.4	24,844
286.60	7.6	2,376	289.20	80.9	25,325
286.65	8.9	2,777	289.25	82.5	25,808
286.70	10.2	3,180	289.30	84.0	26,292
286.75	11.5	3,585	289.35	85.6	26,778
286.80	12.8	3,991	289.40	87.1	27,265
286.85	14.1	4,398	289.45	88.7	27,754
286.90	15.4	4,808	289.50	90.2	28,245
286.95	16.7	5,218	289.55	91.8	28,737
287.00	18.0	5,631	289.60	93.4	29,231
287.05	19.3	6,045	289.65	95.0	29,726
287.10	20.6	6,460	289.70	96.6	30,223
287.15	22.0	6,877	289.75	98.2	30,722
287.20	23.3	7,296	289.80	99.8	31,222
287.25	24.7	7,716	289.85	101.4	31,723
287.30	26.0	8,138	289.90	103.0	32,226
287.35	27.4	8,561	289.95	104.6	32,731
287.40	28.7	8,986	290.00	106.2	33,237
287.45	30.1	9,413	290.05	107.8	33,745
287.50	31.4	9,841	290.10	109.4	34,255
287.55	32.8	10,270	290.15	111.1	34,766
287.60	34.2	10,701	290.20	112.7	35,278
287.65	35.6	11,134	290.25	114.4	35,792
287.70	37.0	11,568	290.30	116.0	36,308
287.75	38.4	12,004	290.35	117.7	36,825
287.80	39.8	12,442	290.40	119.3	37,344
287.85	41.2	12,881	290.45	121.0	37,864
287.90	42.6	13,321	290.50	122.6	38,386
287.95	44.0	13,763	290.55	124.3	38,910
288.00	45.4	14,207	290.60	126.0	39,435
288.05	46.8	14,652	290.65	127.7	39,961
288.10	48.2	15,099	290.70	129.4	40,490
288.15	49.7	15,547	290.75	131.1	41,019
288.20	51.1	15,997	290.80	132.8	41,551
288.25	52.6	16,449	290.85	134.5	42,084
288.30	54.0	16,902	290.90	136.2	42,618
288.35	55.5	17,357	290.95	137.9	43,154
288.40	56.9	17,813	291.00	139.6	43,692
288.45	58.4	18,271	291.05	141.3	44,231
288.50	59.8	18,730	291.10	143.0	44,772
288.55	61.3	19,191	291.15	144.8	45,314
288.60	62.8	19,653	291.20	146.5	45,858
288.65	64.3	20,117	291.25	148.3	46,403
288.70	65.8	20,583	291.30	**150.0**	**46,950**
288.75	67.3	21,050			
288.80	68.8	21,519			
288.85	70.3	21,989			

Summary for Pond 1P: Main Basin

Assumed top of bank at 290. Assumed overtopping at 289.9 to avoid modeling error.

Inflow Area = 73.730 ac, 17.24% Impervious, Inflow Depth = 17.74" for Half PMF event
Inflow = 491.93 cfs @ 0.76 hrs, Volume= 108.980 af
Outflow = 112.92 cfs @ 4.90 hrs, Volume= 109.854 af, Atten= 77%, Lag= 248.4 min
Primary = 112.92 cfs @ 4.90 hrs, Volume= 109.854 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 286.00' Surf.Area= 10.240 ac Storage= 147.842 af
Peak Elev= 288.42' @ 4.83 hrs Surf.Area= 14.533 ac Storage= 178.535 af (30.694 af above start)
Flood Elev= 290.00' Surf.Area= 14.533 ac Storage= 201.556 af (53.714 af above start)

Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= 215.7 min (592.2 - 376.5)

Volume	Invert	Avail.Storage	Storage Description
#1	260.00'	201.556 af	**Custom Stage Data (Irregular)** Listed below (Recalc)

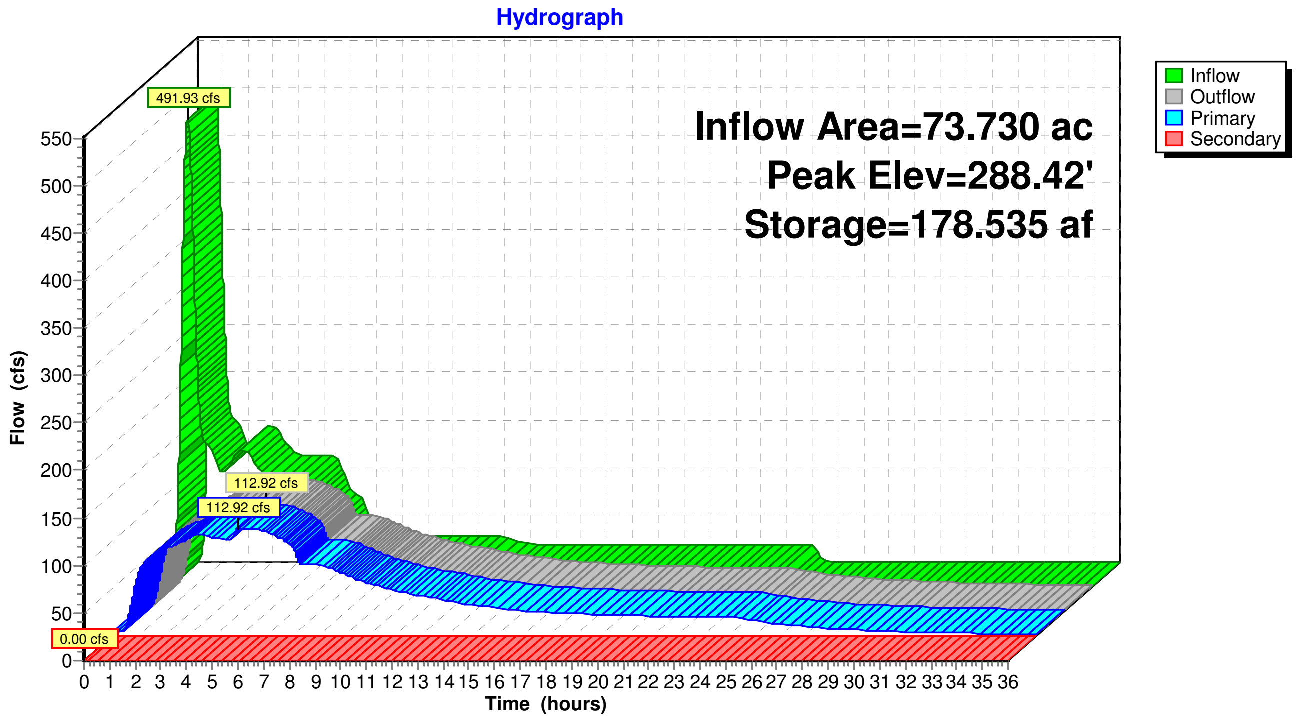
Elevation (feet)	Surf.Area (acres)	Perim. (feet)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
260.00	1.269	893.1	0.000	0.000	1.269
264.00	2.990	1,479.1	8.276	8.276	3.811
270.00	4.772	2,018.6	23.079	31.355	7.267
276.00	6.477	2,564.3	33.617	64.972	11.846
286.00	10.240	2,939.0	82.870	147.842	15.666
288.00	14.533	7,373.0	24.648	172.490	99.196
290.00	14.533	7,373.0	29.066	201.556	99.534

Device	Routing	Invert	Outlet Devices
#1	Secondary	289.90'	**850.0' long x 15.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#2	Primary	285.75'	**4.5' long Sharp-Crested Rectangular Weir X 2.00** 2 End Contraction(s)

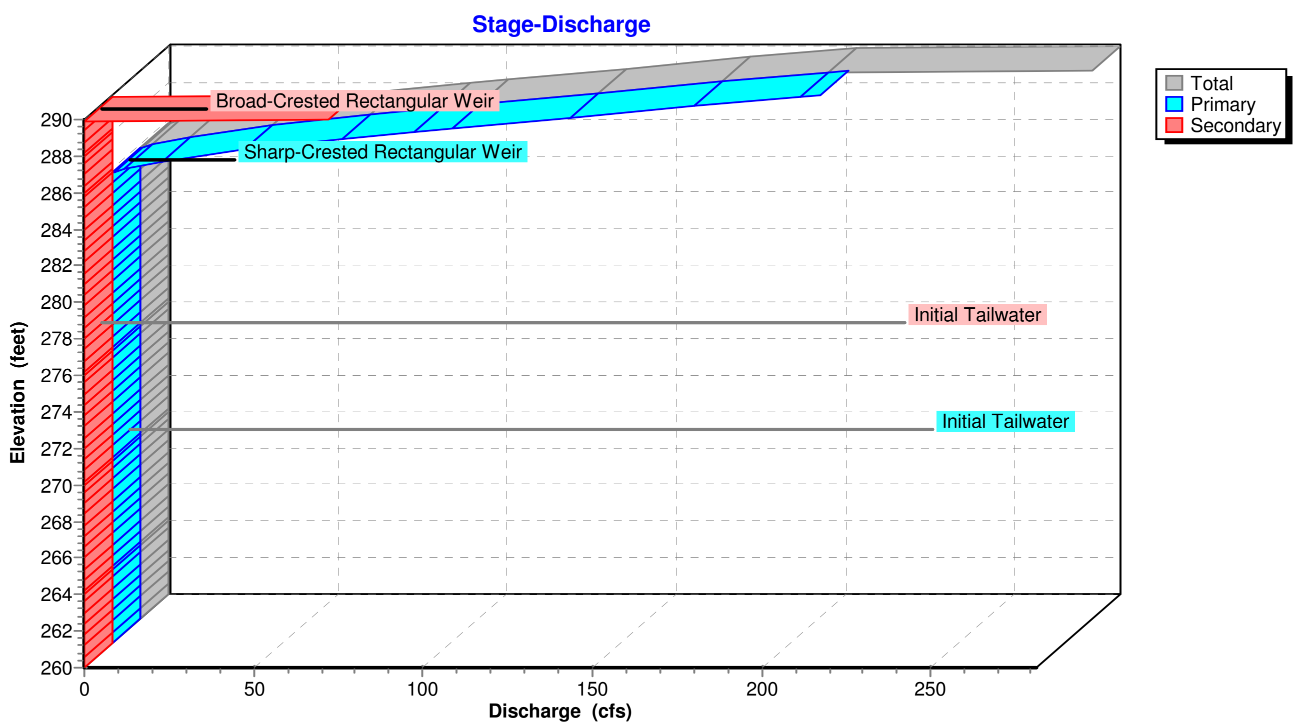
Primary OutFlow Max=69.50 cfs @ 4.90 hrs HW=288.42' TW=287.88' (Dynamic Tailwater)
↑—**2=Sharp-Crested Rectangular Weir** (Weir Controls 69.50 cfs @ 3.29 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=286.00' TW=278.20' (Dynamic Tailwater)
↑—**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

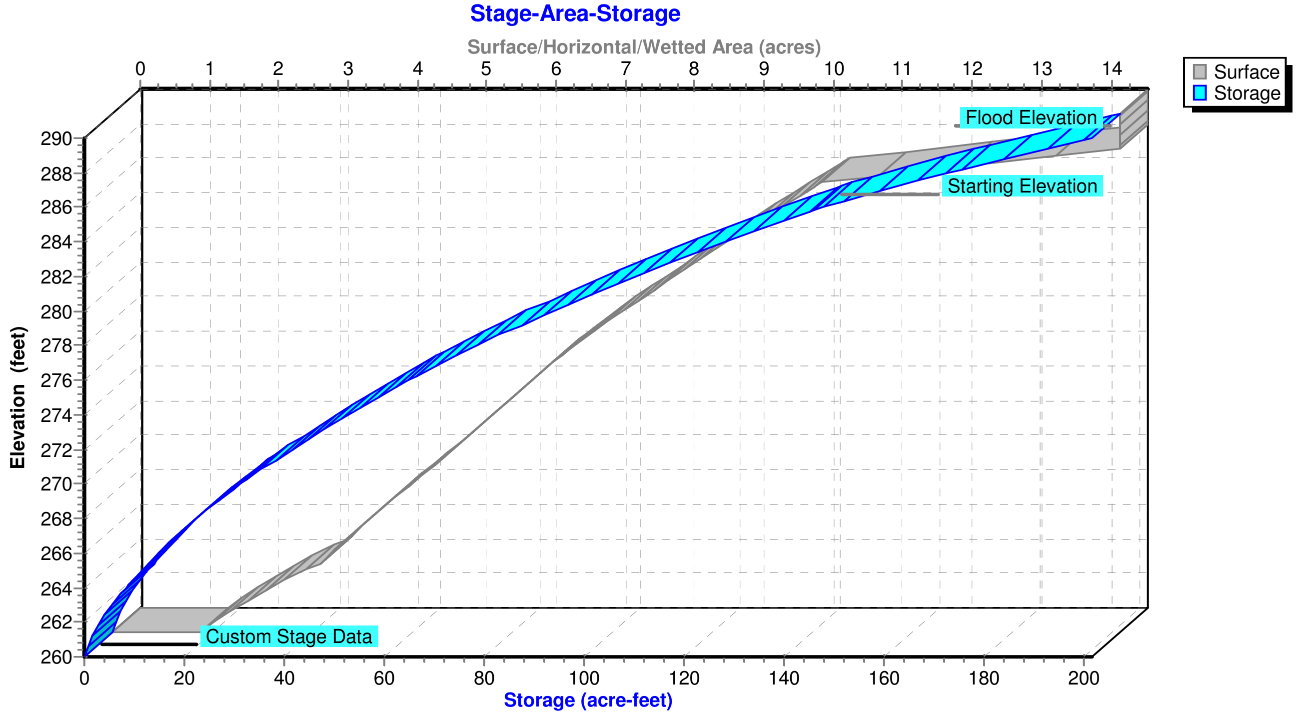
Pond 1P: Main Basin



Pond 1P: Main Basin



Pond 1P: Main Basin



Hydrograph for Pond 1P: Main Basin

Time (hours)	Inflow (cfs)	Storage (acre-feet)	Elevation (feet)	Outflow (cfs)	Primary (cfs)	Secondary (cfs)
0.00	**0.00**	147.842	286.00	3.64	3.64	**0.00**
1.00	**347.73**	165.608	287.51	63.20	63.20	0.00
2.00	124.88	173.060	288.04	91.59	91.59	0.00
3.00	143.95	176.066	288.25	103.26	103.26	0.00
4.00	113.34	**177.893**	**288.37**	**103.43**	**103.43**	0.00
5.00	112.52	**178.530**	**288.42**	**112.91**	**112.91**	0.00
6.00	76.63	177.731	288.36	109.74	109.74	0.00
7.00	30.98	174.050	288.11	95.36	95.36	0.00
8.00	27.41	169.830	287.81	74.82	74.82	0.00
9.00	27.49	166.228	287.55	65.56	65.56	0.00
10.00	27.26	163.535	287.35	55.35	55.35	0.00
11.00	27.70	161.562	287.20	47.95	47.95	0.00
12.00	27.65	160.118	287.08	42.60	42.60	0.00
13.00	19.32	158.713	286.97	37.47	37.47	0.00
14.00	19.25	157.412	286.86	32.79	32.79	0.00
15.00	19.26	156.442	286.78	29.37	29.37	0.00
16.00	19.26	155.716	286.72	26.84	26.84	0.00
17.00	19.26	155.171	286.67	24.97	24.97	0.00
18.00	19.27	154.759	286.64	23.58	23.58	0.00
19.00	19.27	154.448	286.61	22.54	22.54	0.00
20.00	19.27	154.212	286.59	21.75	21.75	0.00
21.00	19.28	154.033	286.57	21.16	21.16	0.00
22.00	19.28	153.897	286.56	20.71	20.71	0.00
23.00	19.28	153.793	286.55	20.37	20.37	0.00
24.00	19.28	153.715	286.54	20.11	20.11	0.00
25.00	0.00	152.563	286.44	16.42	16.42	0.00
26.00	0.00	151.364	286.33	12.77	12.77	0.00
27.00	0.00	150.426	286.25	10.07	10.07	0.00
28.00	0.00	149.681	286.18	8.05	8.05	0.00
29.00	0.00	149.083	286.12	6.51	6.51	0.00
30.00	0.00	148.596	286.07	5.33	5.33	0.00
31.00	0.00	148.195	286.03	4.41	4.41	0.00
32.00	0.00	147.862	286.00	3.68	3.68	0.00
33.00	0.00	147.582	285.97	3.10	3.10	0.00
34.00	0.00	147.346	285.95	2.64	2.64	0.00
35.00	0.00	147.144	285.93	2.26	2.26	0.00
36.00	0.00	146.970	285.91	1.95	1.95	0.00

Stage-Discharge for Pond 1P: Main Basin

Elevation (feet)	Discharge (cfs)	Primary (cfs)	Secondary (cfs)	Elevation (feet)	Discharge (cfs)	Primary (cfs)	Secondary (cfs)
260.00	0.00	0.00	0.00	275.60	0.00	0.00	0.00
260.30	0.00	0.00	0.00	275.90	0.00	0.00	0.00
260.60	0.00	0.00	0.00	276.20	0.00	0.00	0.00
260.90	0.00	0.00	0.00	276.50	0.00	0.00	0.00
261.20	0.00	0.00	0.00	276.80	0.00	0.00	0.00
261.50	0.00	0.00	0.00	277.10	0.00	0.00	0.00
261.80	0.00	0.00	0.00	277.40	0.00	0.00	0.00
262.10	0.00	0.00	0.00	277.70	0.00	0.00	0.00
262.40	0.00	0.00	0.00	278.00	0.00	0.00	0.00
262.70	0.00	0.00	0.00	278.30	0.00	0.00	0.00
263.00	0.00	0.00	0.00	278.60	0.00	0.00	0.00
263.30	0.00	0.00	0.00	278.90	0.00	0.00	0.00
263.60	0.00	0.00	0.00	279.20	0.00	0.00	0.00
263.90	0.00	0.00	0.00	279.50	0.00	0.00	0.00
264.20	0.00	0.00	0.00	279.80	0.00	0.00	0.00
264.50	0.00	0.00	0.00	280.10	0.00	0.00	0.00
264.80	0.00	0.00	0.00	280.40	0.00	0.00	0.00
265.10	0.00	0.00	0.00	280.70	0.00	0.00	0.00
265.40	0.00	0.00	0.00	281.00	0.00	0.00	0.00
265.70	0.00	0.00	0.00	281.30	0.00	0.00	0.00
266.00	0.00	0.00	0.00	281.60	0.00	0.00	0.00
266.30	0.00	0.00	0.00	281.90	0.00	0.00	0.00
266.60	0.00	0.00	0.00	282.20	0.00	0.00	0.00
266.90	0.00	0.00	0.00	282.50	0.00	0.00	0.00
267.20	0.00	0.00	0.00	282.80	0.00	0.00	0.00
267.50	0.00	0.00	0.00	283.10	0.00	0.00	0.00
267.80	0.00	0.00	0.00	283.40	0.00	0.00	0.00
268.10	0.00	0.00	0.00	283.70	0.00	0.00	0.00
268.40	0.00	0.00	0.00	284.00	0.00	0.00	0.00
268.70	0.00	0.00	0.00	284.30	0.00	0.00	0.00
269.00	0.00	0.00	0.00	284.60	0.00	0.00	0.00
269.30	0.00	0.00	0.00	284.90	0.00	0.00	0.00
269.60	0.00	0.00	0.00	285.20	0.00	0.00	0.00
269.90	0.00	0.00	0.00	285.50	0.00	0.00	0.00
270.20	0.00	0.00	0.00	285.80	0.33	0.33	0.00
270.50	0.00	0.00	0.00	286.10	6.00	6.00	0.00
270.80	0.00	0.00	0.00	286.40	14.98	14.98	0.00
271.10	0.00	0.00	0.00	286.70	26.10	26.10	0.00
271.40	0.00	0.00	0.00	287.00	38.84	38.84	0.00
271.70	0.00	0.00	0.00	287.30	52.88	52.88	0.00
272.00	0.00	0.00	0.00	287.60	67.97	67.97	0.00
272.30	0.00	0.00	0.00	287.90	83.91	83.91	0.00
272.60	0.00	0.00	0.00	288.20	100.57	100.57	0.00
272.90	0.00	0.00	0.00	288.50	117.81	117.81	0.00
273.20	0.00	0.00	0.00	288.80	135.51	135.51	0.00
273.50	0.00	0.00	0.00	289.10	153.58	153.58	0.00
273.80	0.00	0.00	0.00	289.40	171.93	171.93	0.00
274.10	0.00	0.00	0.00	289.70	190.48	190.48	0.00
274.40	0.00	0.00	0.00	290.00	**281.18**	**209.15**	**72.04**
274.70	0.00	0.00	0.00				
275.00	0.00	0.00	0.00				
275.30	0.00	0.00	0.00				

Stage-Area-Storage for Pond 1P: Main Basin

Elevation (feet)	Surface (acres)	Storage (acre-feet)	Elevation (feet)	Surface (acres)	Storage (acre-feet)
260.00	1.269	0.000	275.60	6.355	62.405
260.30	1.373	0.396	275.90	6.446	64.325
260.60	1.481	0.824	276.20	6.544	66.274
260.90	1.593	1.285	276.50	6.645	68.252
261.20	1.709	1.780	276.80	6.746	70.261
261.50	1.829	2.311	277.10	6.849	72.300
261.80	1.954	2.878	277.40	6.952	74.370
262.10	2.082	3.483	277.70	7.056	76.471
262.40	2.214	4.128	278.00	7.161	78.604
262.70	2.351	4.813	278.30	7.267	80.768
263.00	2.492	5.539	278.60	7.373	82.964
263.30	2.636	6.308	278.90	7.480	85.192
263.60	2.785	7.121	279.20	7.588	87.452
263.90	2.938	7.979	279.50	7.696	89.744
264.20	3.043	8.879	279.80	7.806	92.070
264.50	3.123	9.804	280.10	7.916	94.428
264.80	3.204	10.753	280.40	8.027	96.819
265.10	3.286	11.726	280.70	8.139	99.244
265.40	3.369	12.724	281.00	8.251	101.703
265.70	3.453	13.748	281.30	8.365	104.195
266.00	3.538	14.796	281.60	8.479	106.722
266.30	3.624	15.870	281.90	8.593	109.282
266.60	3.711	16.971	282.20	8.709	111.878
266.90	3.800	18.097	282.50	8.825	114.508
267.20	3.889	19.250	282.80	8.942	117.173
267.50	3.979	20.431	283.10	9.060	119.873
267.80	4.070	21.638	283.40	9.179	122.609
268.10	4.163	22.873	283.70	9.299	125.381
268.40	4.256	24.136	284.00	9.419	128.188
268.70	4.351	25.427	284.30	9.540	131.032
269.00	4.446	26.746	284.60	9.662	133.912
269.30	4.543	28.095	284.90	9.784	136.829
269.60	4.640	29.472	285.20	9.907	139.783
269.90	4.739	30.879	285.50	10.031	142.774
270.20	4.825	32.314	285.80	10.156	145.802
270.50	4.904	33.774	286.10	10.437	148.875
270.80	4.984	35.257	286.40	11.039	152.096
271.10	5.065	36.764	286.70	11.657	155.500
271.40	5.147	38.296	287.00	12.293	159.092
271.70	5.229	39.852	287.30	12.945	162.878
272.00	5.311	41.433	287.60	13.614	166.861
272.30	5.395	43.039	287.90	**14.301**	171.048
272.60	5.479	44.670	288.20	**14.533**	175.396
272.90	5.564	46.327	288.50	14.533	179.756
273.20	5.649	48.008	288.80	14.533	184.116
273.50	5.735	49.716	289.10	14.533	188.476
273.80	5.822	51.449	289.40	14.533	192.836
274.10	5.909	53.209	289.70	14.533	197.196
274.40	5.997	54.995	290.00	14.533	**201.556**
274.70	6.086	56.807			
275.00	6.175	58.646			
275.30	6.265	60.512			

Summary for Pond 2P: Polishing Pond

Assumed top of bank at 290. Assumed overtopping at 289.9 to avoid modeling error.

Inflow Area = 76.440 ac, 19.10% Impervious, Inflow Depth > 17.91" for Half PMF event
Inflow = 117.10 cfs @ 4.90 hrs, Volume= 114.055 af
Outflow = 100.96 cfs @ 6.77 hrs, Volume= 105.582 af, Atten= 14%, Lag= 111.9 min
Primary = 100.96 cfs @ 6.77 hrs, Volume= 105.608 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 268.00' Surf.Area= 26,962 sf Storage= 219,307 cf
Peak Elev= 285.58' @ 6.77 hrs Surf.Area= 85,511 sf Storage= 1,053,313 cf (834,007 cf above start)
Flood Elev= 290.00' Surf.Area= 98,990 sf Storage= 1,474,008 cf (1,254,702 cf above start)

Plug-Flow detention time= 236.2 min calculated for 100.546 af (88% of inflow)
Center-of-Mass det. time= 86.1 min (669.5 - 583.3)

Volume	Invert	Avail.Storage	Storage Description
#1	254.00'	1,474,008 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

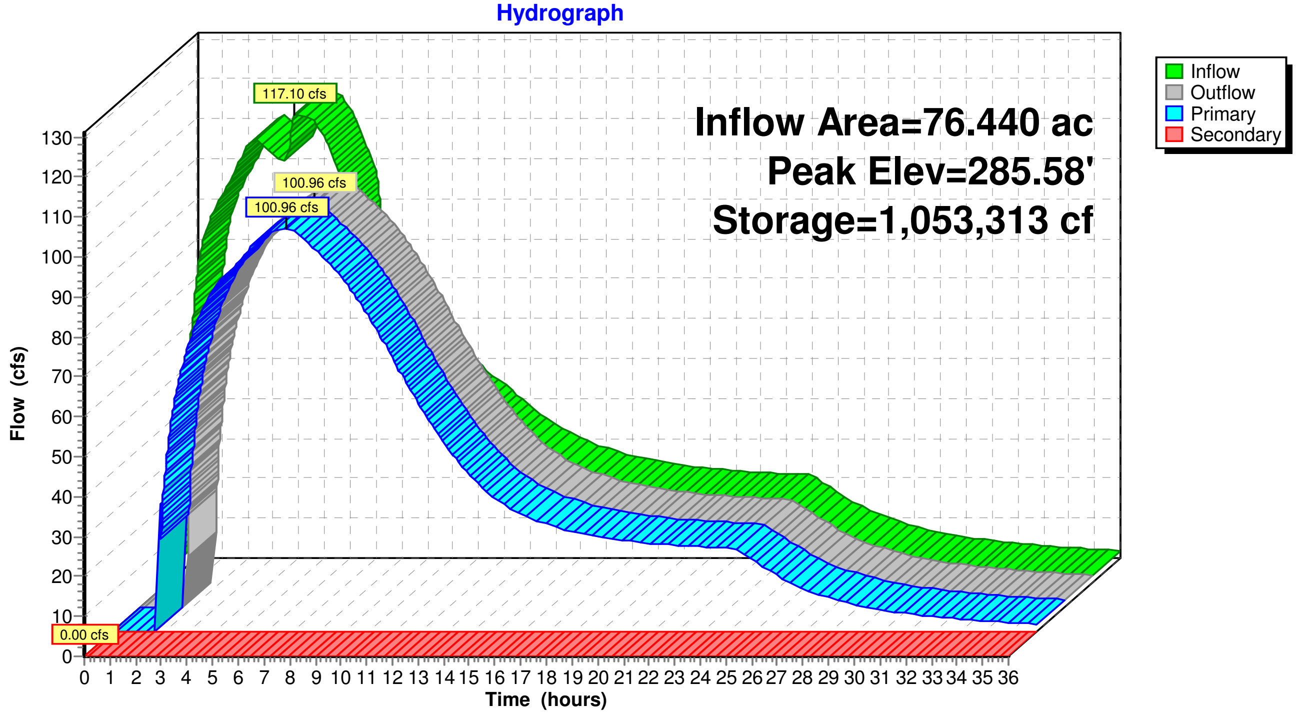
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
254.00	2,693	202.2	0	0	2,693
260.00	15,830	477.0	50,104	50,104	17,685
270.00	30,205	648.0	226,338	276,443	33,994
280.00	50,453	833.6	398,985	675,428	57,097
285.00	82,403	1,143.9	328,891	1,004,319	106,177
288.00	98,990	1,266.3	271,710	1,276,028	129,929
290.00	98,990	1,266.3	197,980	1,474,008	132,462

Device	Routing	Invert	Outlet Devices
#1	Secondary	289.90'	**650.0' long x 15.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#2	Primary	268.00'	**30.0" Horiz. Orifice/Grate X 2.00** C= 0.600 Limited to weir flow at low heads

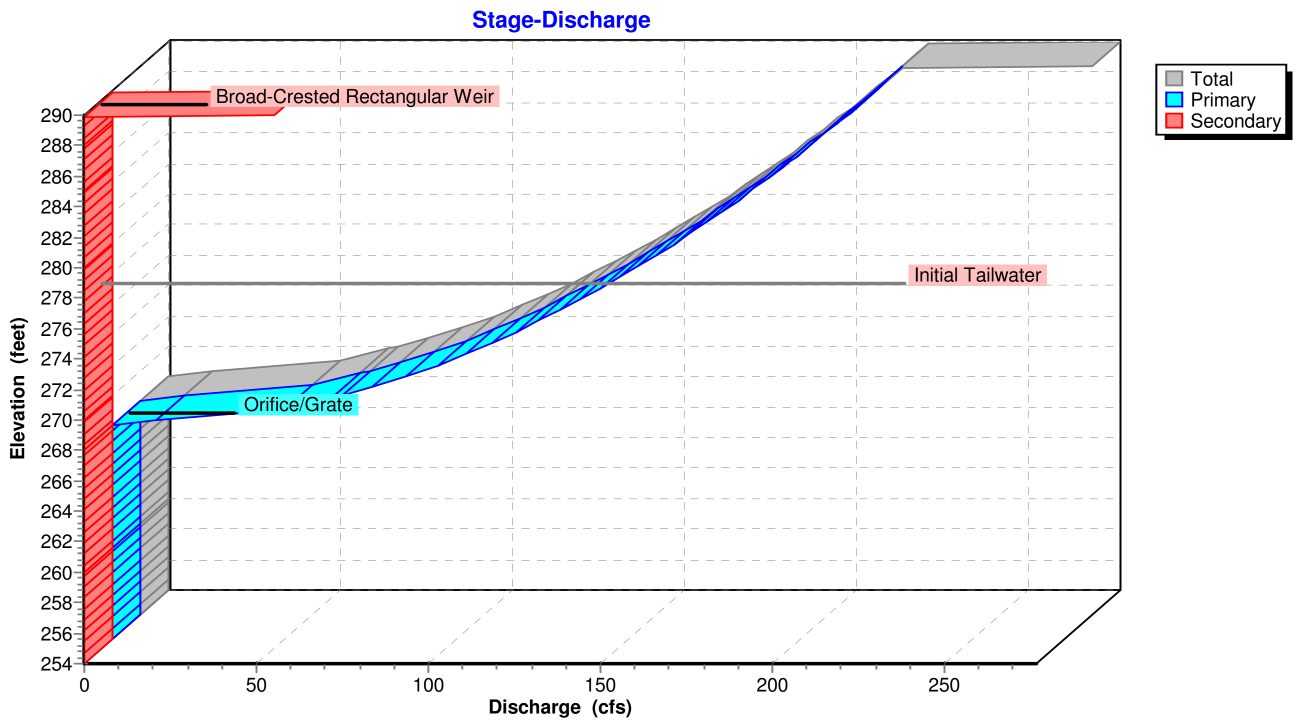
Primary OutFlow Max=100.57 cfs @ 6.77 hrs HW=285.58' TW=281.06' (Dynamic Tailwater)
└─**2=Orifice/Grate** (Orifice Controls 100.57 cfs @ 10.24 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=268.00' TW=278.20' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

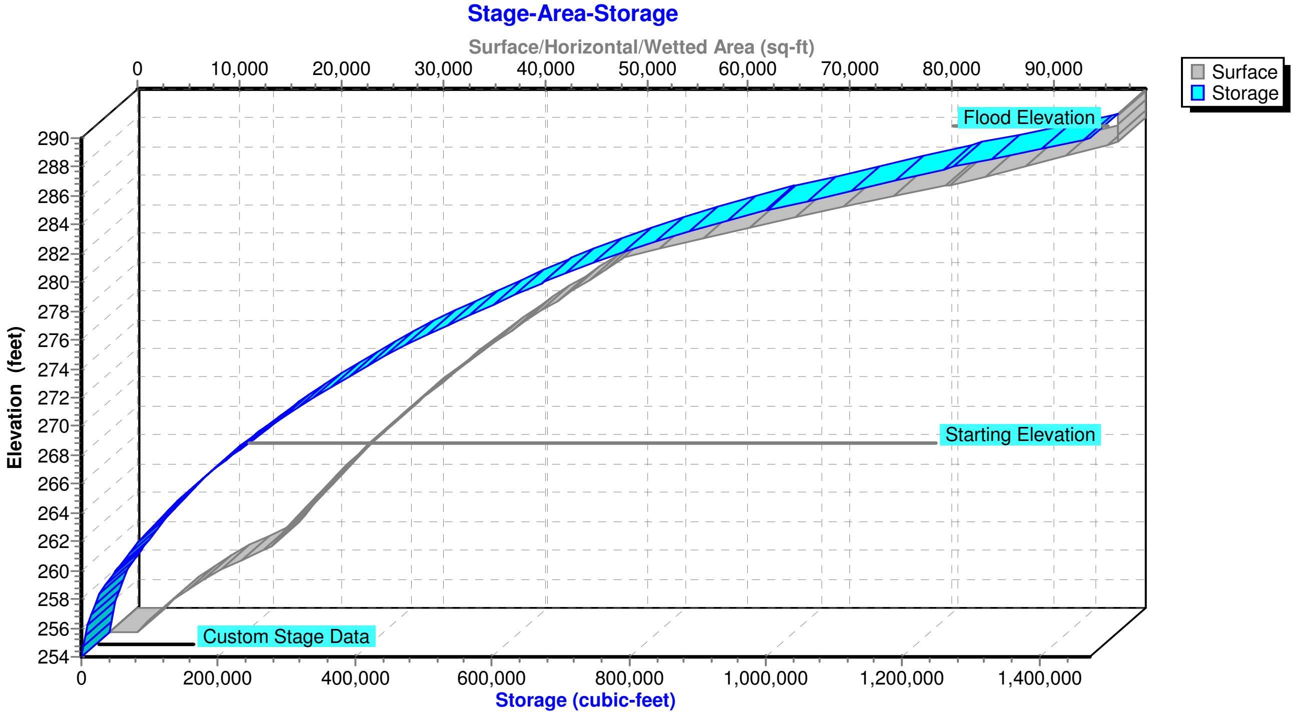
Pond 2P: Polishing Pond



Pond 2P: Polishing Pond



Pond 2P: Polishing Pond



Hydrograph for Pond 2P: Polishing Pond

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)	Primary (cfs)	Secondary (cfs)
0.00	3.64	219,372	268.00	0.00	0.01	**0.00**
1.00	68.86	333,772	271.80	0.00	0.00	0.00
2.00	95.89	633,134	279.15	35.49	35.49	0.00
3.00	108.49	790,069	282.03	72.45	72.45	0.00
4.00	**107.58**	896,743	283.61	86.18	86.18	0.00
5.00	**117.08**	965,625	284.52	93.27	93.27	0.00
6.00	112.38	**1,034,337**	**285.36**	**99.43**	**99.43**	0.00
7.00	96.38	**1,051,505**	**285.56**	**100.75**	**100.75**	0.00
8.00	75.85	985,430	284.77	95.04	95.04	0.00
9.00	66.58	914,936	283.86	88.24	88.24	0.00
10.00	56.36	833,914	282.71	78.80	78.80	0.00
11.00	48.97	758,882	281.52	67.63	67.63	0.00
12.00	43.61	702,000	280.51	56.43	56.43	0.00
13.00	38.18	664,362	279.78	46.64	46.64	0.00
14.00	33.50	640,019	279.29	38.68	38.68	0.00
15.00	30.08	625,736	278.99	33.02	33.02	0.00
16.00	27.56	617,592	278.82	29.27	29.27	0.00
17.00	25.69	612,715	278.72	26.75	26.75	0.00
18.00	24.29	609,586	278.65	25.00	25.00	0.00
19.00	23.25	607,470	278.61	23.74	23.74	0.00
20.00	22.46	605,989	278.58	22.81	22.81	0.00
21.00	21.87	604,927	278.56	22.12	22.12	0.00
22.00	21.42	604,155	278.54	21.60	21.60	0.00
23.00	21.08	603,586	278.53	21.22	21.22	0.00
24.00	20.82	603,164	278.52	20.92	20.92	0.00
25.00	16.42	599,148	278.43	17.92	17.92	0.00
26.00	12.77	594,627	278.34	13.73	13.73	0.00
27.00	10.07	592,049	278.28	10.59	10.59	0.00
28.00	8.05	590,612	278.25	8.35	8.35	0.00
29.00	6.51	589,772	278.23	6.69	6.69	0.00
30.00	5.33	589,259	278.22	5.44	5.44	0.00
31.00	4.41	588,938	278.21	4.48	4.48	0.00
32.00	3.68	588,730	278.21	3.73	3.73	0.00
33.00	3.10	588,593	278.21	3.13	3.13	0.00
34.00	2.64	588,500	278.21	2.66	2.66	0.00
35.00	2.26	588,436	278.20	2.28	2.28	0.00
36.00	1.95	588,391	278.20	1.96	1.96	0.00

Stage-Discharge for Pond 2P: Polishing Pond

Elevation (feet)	Discharge (cfs)	Primary (cfs)	Secondary (cfs)	Elevation (feet)	Discharge (cfs)	Primary (cfs)	Secondary (cfs)
254.00	0.00	0.00	0.00	274.80	123.27	123.27	0.00
254.40	0.00	0.00	0.00	275.20	126.84	126.84	0.00
254.80	0.00	0.00	0.00	275.60	130.32	130.32	0.00
255.20	0.00	0.00	0.00	276.00	133.70	133.70	0.00
255.60	0.00	0.00	0.00	276.40	137.00	137.00	0.00
256.00	0.00	0.00	0.00	276.80	140.23	140.23	0.00
256.40	0.00	0.00	0.00	277.20	143.38	143.38	0.00
256.80	0.00	0.00	0.00	277.60	146.46	146.46	0.00
257.20	0.00	0.00	0.00	278.00	149.48	149.48	0.00
257.60	0.00	0.00	0.00	278.40	152.44	152.44	0.00
258.00	0.00	0.00	0.00	278.80	155.35	155.35	0.00
258.40	0.00	0.00	0.00	279.20	158.20	158.20	0.00
258.80	0.00	0.00	0.00	279.60	161.00	161.00	0.00
259.20	0.00	0.00	0.00	280.00	163.75	163.75	0.00
259.60	0.00	0.00	0.00	280.40	166.46	166.46	0.00
260.00	0.00	0.00	0.00	280.80	169.12	169.12	0.00
260.40	0.00	0.00	0.00	281.20	171.74	171.74	0.00
260.80	0.00	0.00	0.00	281.60	174.33	174.33	0.00
261.20	0.00	0.00	0.00	282.00	176.87	176.87	0.00
261.60	0.00	0.00	0.00	282.40	179.38	179.38	0.00
262.00	0.00	0.00	0.00	282.80	181.85	181.85	0.00
262.40	0.00	0.00	0.00	283.20	184.30	184.30	0.00
262.80	0.00	0.00	0.00	283.60	186.71	186.71	0.00
263.20	0.00	0.00	0.00	284.00	189.08	189.08	0.00
263.60	0.00	0.00	0.00	284.40	191.43	191.43	0.00
264.00	0.00	0.00	0.00	284.80	193.75	193.75	0.00
264.40	0.00	0.00	0.00	285.20	196.05	196.05	0.00
264.80	0.00	0.00	0.00	285.60	198.31	198.31	0.00
265.20	0.00	0.00	0.00	286.00	200.55	200.55	0.00
265.60	0.00	0.00	0.00	286.40	202.77	202.77	0.00
266.00	0.00	0.00	0.00	286.80	204.96	204.96	0.00
266.40	0.00	0.00	0.00	287.20	207.13	207.13	0.00
266.80	0.00	0.00	0.00	287.60	209.28	209.28	0.00
267.20	0.00	0.00	0.00	288.00	211.40	211.40	0.00
267.60	0.00	0.00	0.00	288.40	213.51	213.51	0.00
268.00	0.00	0.00	0.00	288.80	215.59	215.59	0.00
268.40	12.99	12.99	0.00	289.20	217.65	217.65	0.00
268.80	36.75	36.75	0.00	289.60	219.70	219.70	0.00
269.20	51.78	51.78	0.00	290.00	**276.81**	**221.72**	**55.09**
269.60	59.79	59.79	0.00				
270.00	66.85	66.85	0.00				
270.40	73.23	73.23	0.00				
270.80	79.10	79.10	0.00				
271.20	84.56	84.56	0.00				
271.60	89.69	89.69	0.00				
272.00	94.54	94.54	0.00				
272.40	99.16	99.16	0.00				
272.80	103.57	103.57	0.00				
273.20	107.79	107.79	0.00				
273.60	111.86	111.86	0.00				
274.00	115.79	115.79	0.00				
274.40	119.59	119.59	0.00				

Stage-Area-Storage for Pond 2P: Polishing Pond

Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)	Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
254.00	2,693	0	274.80	39,279	442,729
254.40	3,229	1,183	275.20	40,089	458,603
254.80	3,813	2,589	275.60	40,907	474,802
255.20	4,446	4,240	276.00	41,734	491,330
255.60	5,128	6,153	276.40	42,569	508,190
256.00	5,858	8,348	276.80	43,412	525,386
256.40	6,636	10,845	277.20	44,263	542,920
256.80	7,464	13,664	277.60	45,122	560,797
257.20	8,339	16,823	278.00	45,990	579,019
257.60	9,264	20,342	278.40	46,866	597,590
258.00	10,237	24,240	278.80	47,750	616,513
258.40	11,258	28,537	279.20	48,643	635,792
258.80	12,328	33,253	279.60	49,544	655,429
259.20	13,447	38,407	280.00	50,453	675,428
259.60	14,614	44,017	280.40	52,722	696,061
260.00	15,830	50,104	280.80	55,041	717,612
260.40	16,317	56,533	281.20	57,410	740,101
260.80	16,811	63,159	281.60	59,829	763,547
261.20	17,312	69,983	282.00	62,297	787,970
261.60	17,821	77,009	282.40	64,816	813,391
262.00	18,337	84,240	282.80	67,384	839,830
262.40	18,860	91,679	283.20	70,003	867,305
262.80	19,391	99,329	283.60	72,671	895,838
263.20	19,929	107,193	284.00	75,389	925,449
263.60	20,475	115,274	284.40	78,157	956,156
264.00	21,028	123,574	284.80	80,975	987,981
264.40	21,588	132,097	285.20	83,462	1,020,905
264.80	22,155	140,845	285.60	85,599	1,054,716
265.20	22,730	149,822	286.00	87,763	1,089,388
265.60	23,313	159,030	286.40	89,954	1,124,931
266.00	23,903	168,473	286.80	92,173	1,161,355
266.40	24,500	178,153	287.20	94,418	1,198,672
266.80	25,104	188,074	287.60	96,691	1,236,893
267.20	25,716	198,238	288.00	**98,990**	1,276,028
267.60	26,335	208,648	288.40	98,990	1,315,624
268.00	26,962	219,307	288.80	98,990	1,355,220
268.40	27,596	230,218	289.20	98,990	1,394,816
268.80	28,237	241,384	289.60	98,990	1,434,412
269.20	28,886	252,809	290.00	98,990	**1,474,008**
269.60	29,542	264,494			
270.00	30,205	276,443			
270.40	30,916	288,667			
270.80	31,635	301,176			
271.20	32,362	313,976			
271.60	33,098	327,067			
272.00	33,841	340,455			
272.40	34,593	354,141			
272.80	35,354	368,131			
273.20	36,122	382,425			
273.60	36,899	397,030			
274.00	37,684	411,946			
274.40	38,478	427,178			

Summary for Pond 2R: Outlet Pipe

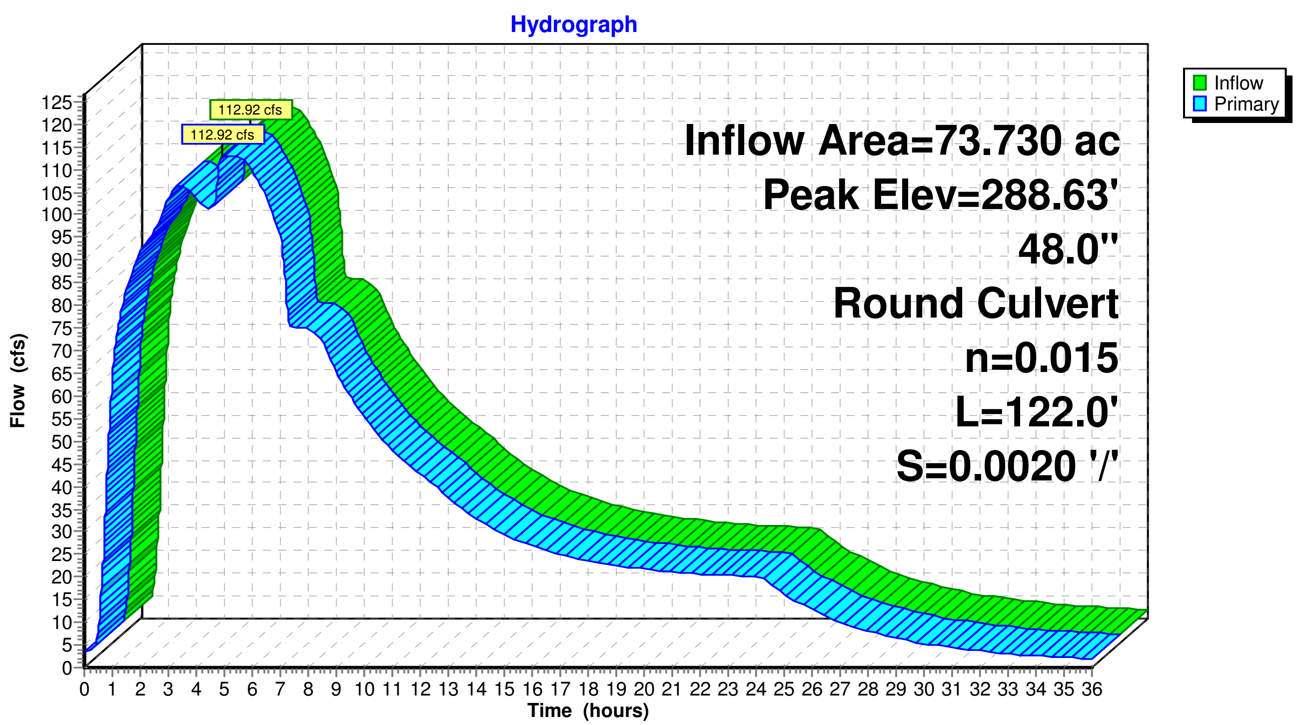
Inflow Area = 73.730 ac, 17.24% Impervious, Inflow Depth > 17.88" for Half PMF event
Inflow = 112.92 cfs @ 4.90 hrs, Volume= 109.854 af
Outflow = 112.92 cfs @ 4.90 hrs, Volume= 109.854 af, Atten= 0%, Lag= 0.0 min
Primary = 112.92 cfs @ 4.90 hrs, Volume= 109.854 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 288.63' @ 5.93 hrs

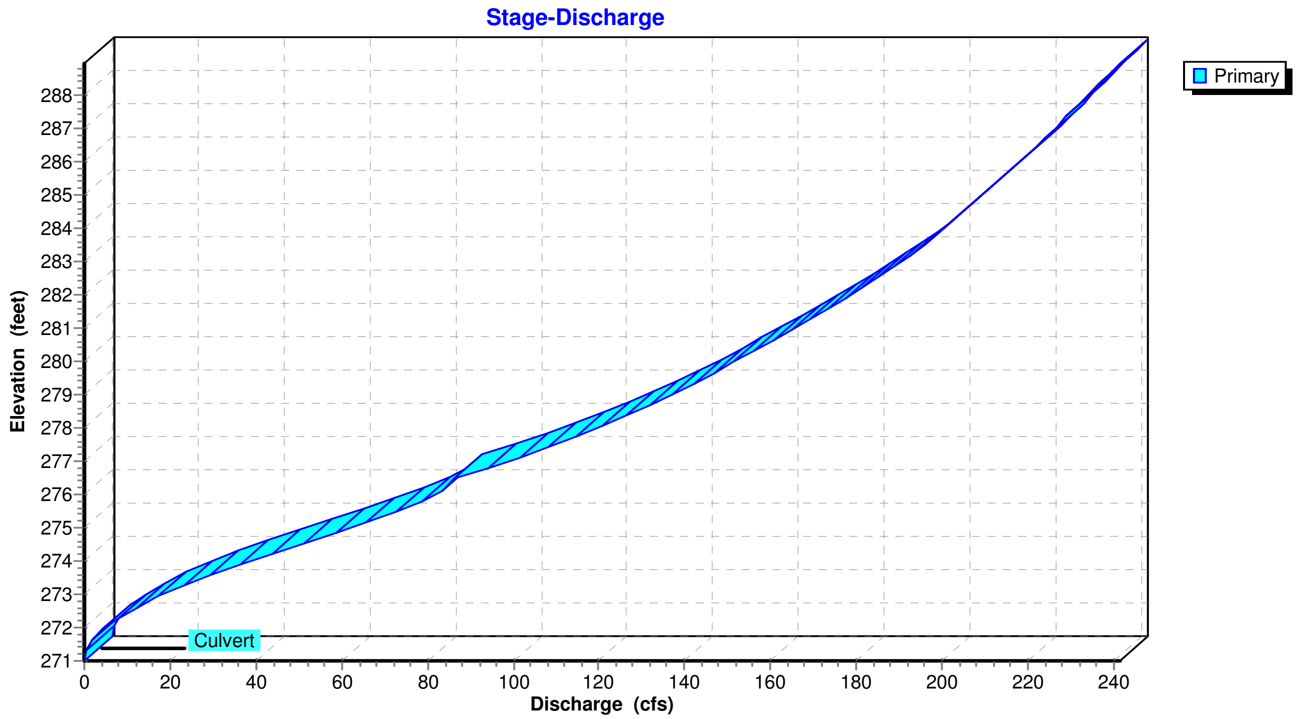
Device	Routing	Invert	Outlet Devices
#1	Primary	271.00'	**48.0" Round Culvert** L= 122.0' Box, headwall w/3 square edges, Ke= 0.500 Outlet Invert= 270.75' S= 0.0020 '/' Cc= 0.900 n= 0.015 Concrete sewer w/manholes & inlets

Primary OutFlow Max=112.76 cfs @ 4.90 hrs HW=287.88' TW=284.41' (Dynamic Tailwater)
↑—**1=Culvert** (Inlet Controls 112.76 cfs @ 8.97 fps)

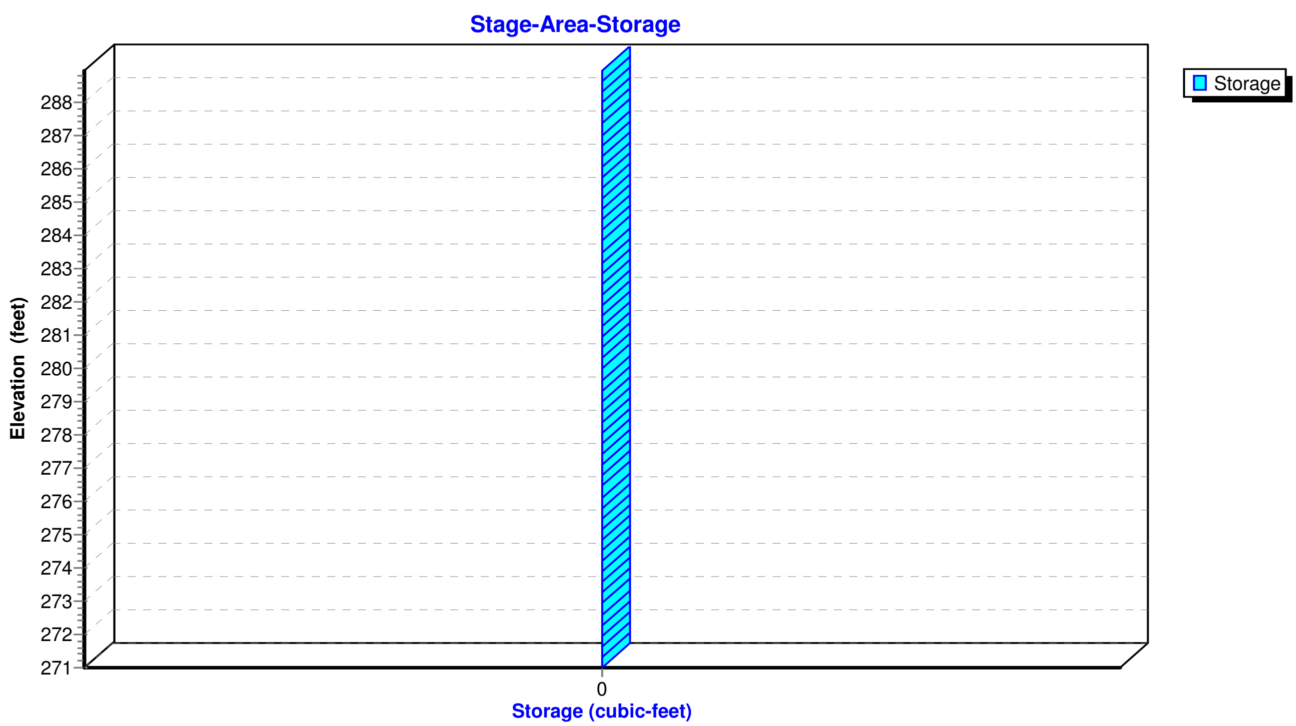
Pond 2R: Outlet Pipe



Pond 2R: Outlet Pipe



Pond 2R: Outlet Pipe



Hydrograph for Pond 2R: Outlet Pipe

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	3.64	271.88	3.64
0.50	8.21	272.31	8.21
1.00	63.20	275.04	63.20
1.50	83.16	277.62	83.16
2.00	91.59	281.44	91.59
2.50	96.40	283.40	96.40
3.00	103.26	284.95	103.26
3.50	106.56	286.06	106.56
4.00	103.43	286.53	103.43
4.50	**101.15**	286.85	**101.15**
5.00	**112.91**	287.99	**112.91**
5.50	112.81	**288.46**	112.81
6.00	109.74	**288.63**	109.74
6.50	103.95	288.48	103.95
7.00	95.36	288.03	95.36
7.50	75.07	286.76	75.07
8.00	74.82	286.30	74.82
8.50	72.01	285.76	72.01
9.00	65.56	285.03	65.56
9.50	60.07	284.29	60.07
10.00	55.35	283.55	55.35
10.50	51.32	282.83	51.32
11.00	47.95	282.15	47.95
11.50	45.04	281.54	45.04
12.00	42.60	281.01	42.60
12.50	40.26	280.56	40.26
13.00	37.47	280.16	37.47
13.50	34.94	279.84	34.94
14.00	32.79	279.58	32.79
14.50	30.95	279.38	30.95
15.00	29.37	279.23	29.37
15.50	28.01	279.11	28.01
16.00	26.84	279.02	26.84
16.50	25.84	278.95	25.84
17.00	24.97	278.89	24.97
17.50	24.23	278.84	24.23
18.00	23.58	278.81	23.58
18.50	23.02	278.77	23.02
19.00	22.54	278.75	22.54
19.50	22.12	278.73	22.12
20.00	21.75	278.71	21.75
20.50	21.43	278.69	21.43
21.00	21.16	278.68	21.16
21.50	20.92	278.67	20.92
22.00	20.71	278.66	20.71
22.50	20.53	278.65	20.53
23.00	20.37	278.64	20.37
23.50	20.23	278.63	20.23
24.00	20.11	278.63	20.11
24.50	18.70	278.58	18.70
25.00	16.42	278.51	16.42
25.50	14.46	278.44	14.46
26.00	12.77	278.38	12.77
26.50	11.32	278.34	11.32
27.00	10.07	278.31	10.07
27.50	8.99	278.29	8.99
28.00	8.05	278.27	8.05
28.50	7.23	278.25	7.23
29.00	6.51	278.24	6.51
29.50	5.88	278.24	5.88
30.00	5.33	278.23	5.33
30.50	4.84	278.22	4.84
31.00	4.41	278.22	4.41
31.50	4.02	278.22	4.02
32.00	3.68	278.21	3.68
32.50	3.38	278.21	3.38
33.00	3.10	278.21	3.10
33.50	2.86	278.21	2.86
34.00	2.64	278.21	2.64
34.50	2.44	278.21	2.44
35.00	2.26	278.21	2.26
35.50	2.10	278.20	2.10
36.00	1.95	278.20	1.95

Stage-Discharge for Pond 2R: Outlet Pipe

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
271.00	0.00	281.40	171.34
271.20	0.15	281.60	173.90
271.40	0.69	281.80	176.42
271.60	1.64	282.00	178.91
271.80	3.00	282.20	181.36
272.00	4.75	282.40	183.77
272.20	6.88	282.60	186.16
272.40	9.37	282.80	188.52
272.60	12.19	283.00	190.85
272.80	15.31	283.20	193.15
273.00	18.72	283.40	195.13
273.20	22.39	283.60	197.00
273.40	26.29	283.80	198.85
273.60	30.40	284.00	200.68
273.80	34.68	284.20	202.49
274.00	39.11	284.40	204.29
274.20	43.66	284.60	206.08
274.40	48.28	284.80	207.85
274.60	52.95	285.00	209.60
274.80	57.61	285.20	211.34
275.00	62.22	285.40	213.07
275.20	66.72	285.60	214.78
275.40	71.04	285.80	216.48
275.60	75.10	286.00	218.16
275.80	78.77	286.20	219.83
276.00	81.87	286.40	221.49
276.20	84.02	286.60	223.14
276.40	85.35	286.80	224.77
276.60	90.37	287.00	226.40
276.80	95.13	287.20	228.01
277.00	99.67	287.40	229.61
277.20	104.00	287.60	231.20
277.40	108.16	287.80	232.77
277.60	112.17	288.00	234.34
277.80	116.04	288.20	235.90
278.00	119.78	288.40	237.45
278.20	123.41	288.60	238.98
278.40	126.94	288.80	**240.51**
278.60	130.37		
278.80	133.72		
279.00	136.98		
279.20	140.16		
279.40	143.28		
279.60	146.33		
279.80	149.31		
280.00	152.24		
280.20	155.11		
280.40	157.94		
280.60	160.71		
280.80	163.43		
281.00	166.11		
281.20	168.75		

Stage-Area-Storage for Pond 2R: Outlet Pipe

Elevation (feet)	Storage (cubic-feet)	Elevation (feet)	Storage (cubic-feet)
271.00	**0**	281.40	0
271.20	0	281.60	0
271.40	0	281.80	0
271.60	0	282.00	0
271.80	0	282.20	0
272.00	0	282.40	0
272.20	0	282.60	0
272.40	0	282.80	0
272.60	0	283.00	0
272.80	0	283.20	0
273.00	0	283.40	0
273.20	0	283.60	0
273.40	0	283.80	0
273.60	0	284.00	0
273.80	0	284.20	0
274.00	0	284.40	0
274.20	0	284.60	0
274.40	0	284.80	0
274.60	0	285.00	0
274.80	0	285.20	0
275.00	0	285.40	0
275.20	0	285.60	0
275.40	0	285.80	0
275.60	0	286.00	0
275.80	0	286.20	0
276.00	0	286.40	0
276.20	0	286.60	0
276.40	0	286.80	0
276.60	0	287.00	0
276.80	0	287.20	0
277.00	0	287.40	0
277.20	0	287.60	0
277.40	0	287.80	0
277.60	0	288.00	0
277.80	0	288.20	0
278.00	0	288.40	0
278.20	0	288.60	0
278.40	0	288.80	0
278.60	0		
278.80	0		
279.00	0		
279.20	0		
279.40	0		
279.60	0		
279.80	0		
280.00	0		
280.20	0		
280.40	0		
280.60	0		
280.80	0		
281.00	0		
281.20	0		

Summary for Pond 3R: Outlet Pipe

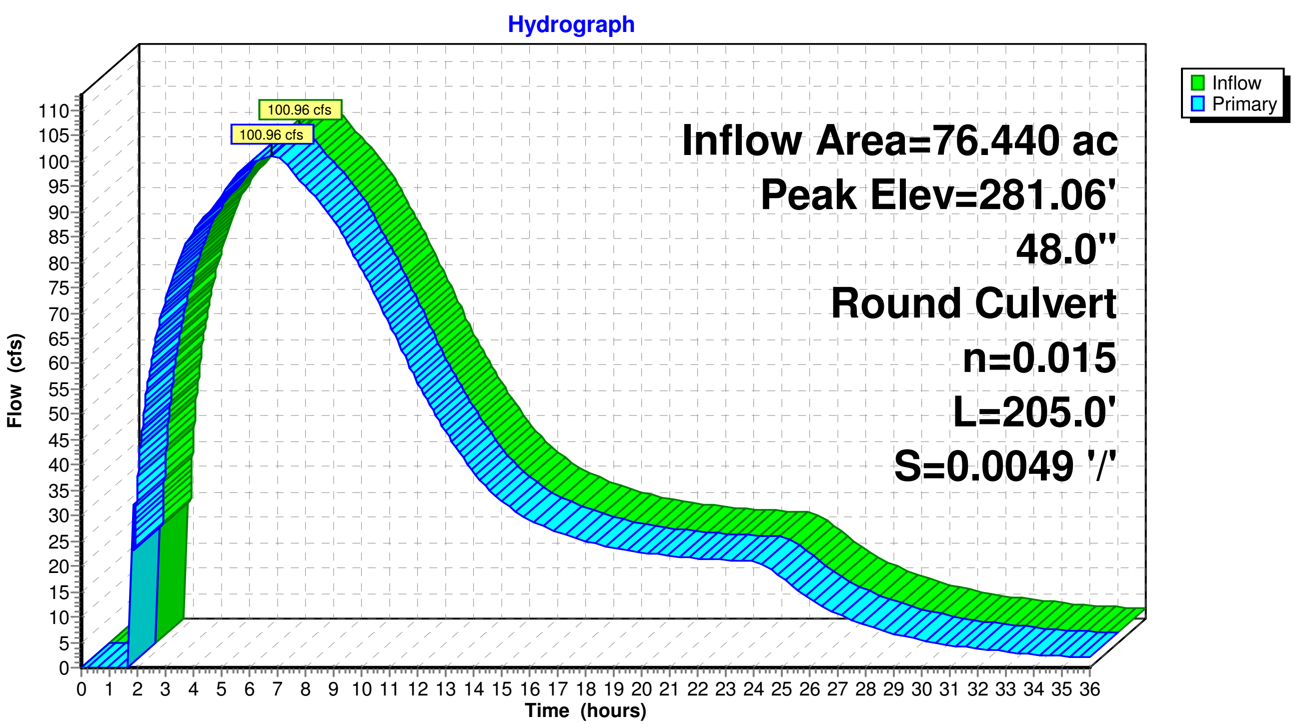
Inflow Area = 76.440 ac, 19.10% Impervious, Inflow Depth > 16.58" for Half PMF event
Inflow = 100.96 cfs @ 6.77 hrs, Volume= 105.608 af
Outflow = 100.96 cfs @ 6.77 hrs, Volume= 105.608 af, Atten= 0%, Lag= 0.0 min
Primary = 100.96 cfs @ 6.77 hrs, Volume= 105.608 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 281.06' @ 6.77 hrs

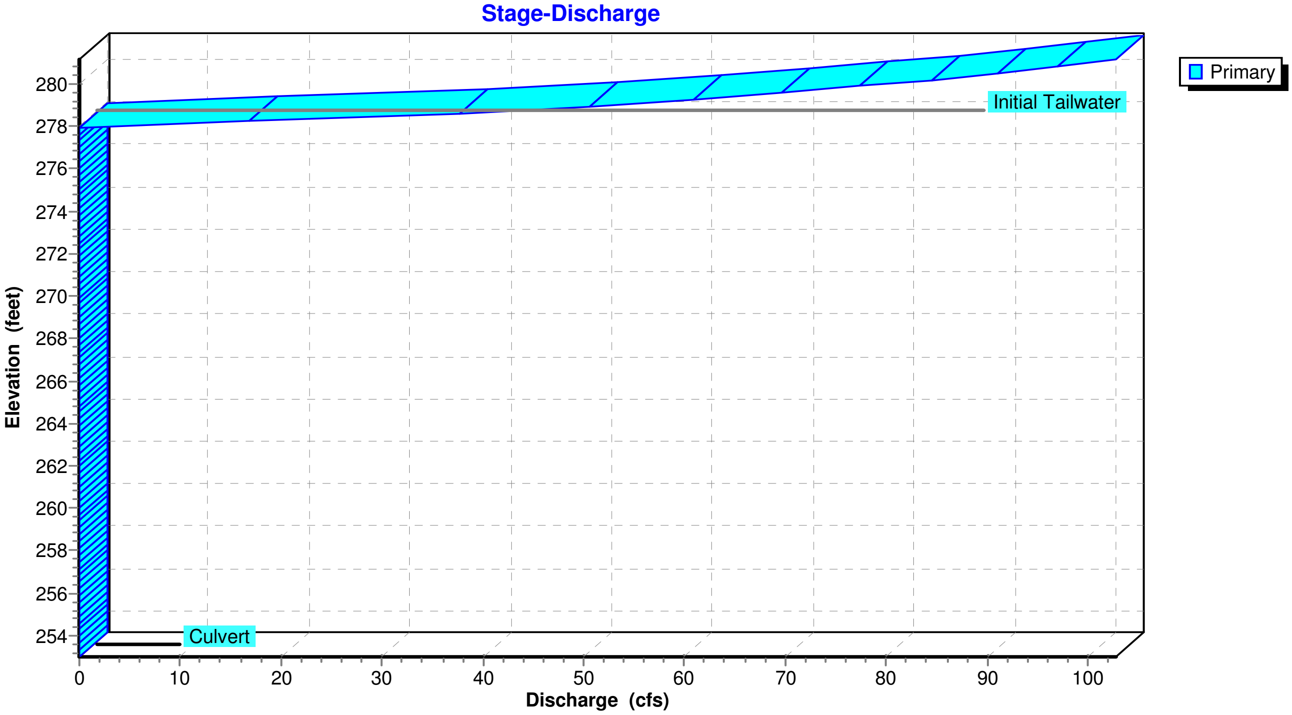
Device	Routing	Invert	Outlet Devices
#1	Primary	253.00'	**48.0" Round Culvert** L= 205.0' Box, headwall w/3 square edges, Ke= 0.500 Outlet Invert= 252.00' S= 0.0049 '/' Cc= 0.900 n= 0.015 Concrete sewer w/manholes & inlets

Primary OutFlow Max=100.96 cfs @ 6.77 hrs HW=281.06' TW=278.20' (Dynamic Tailwater)
↑—**1=Culvert** (Outlet Controls 100.96 cfs @ 8.03 fps)

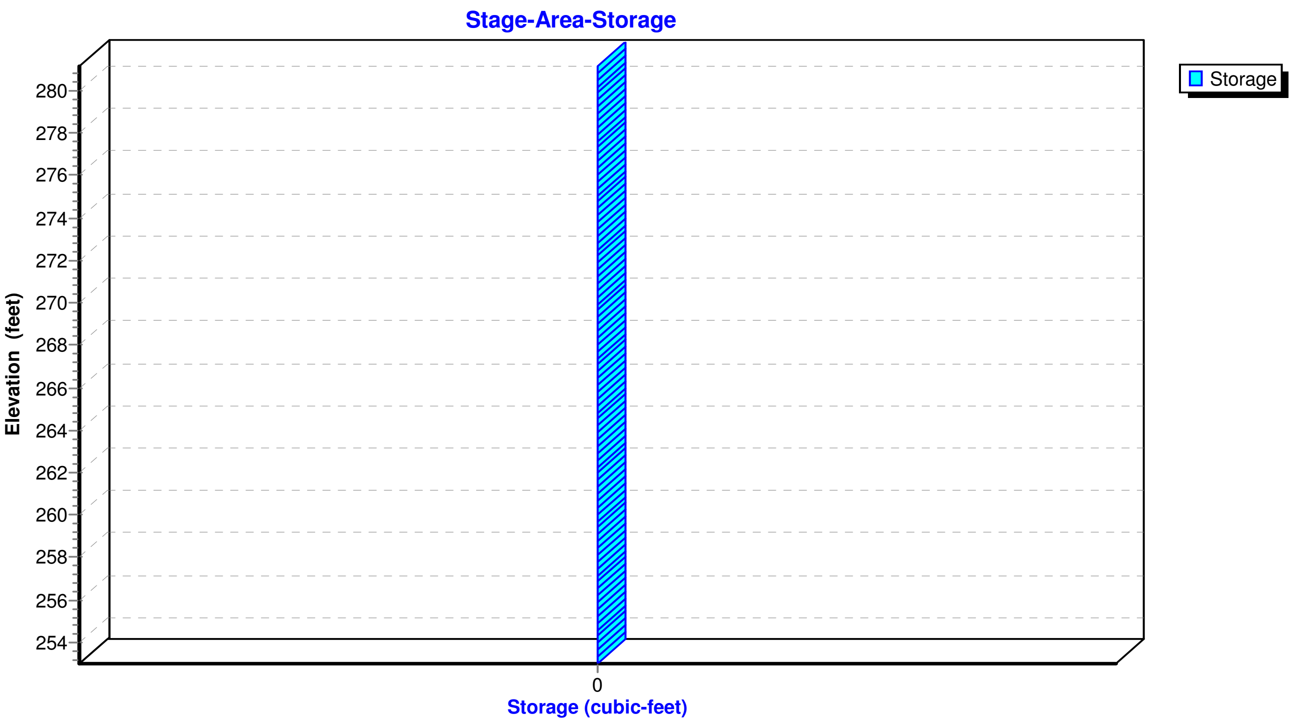
Pond 3R: Outlet Pipe



Pond 3R: Outlet Pipe



Pond 3R: Outlet Pipe



Hydrograph for Pond 3R: Outlet Pipe

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.01	277.96	0.01
0.50	0.00	277.96	0.00
1.00	0.00	277.96	0.00
1.50	0.00	277.96	0.00
2.00	35.49	278.55	35.49
2.50	60.28	279.22	60.28
3.00	72.45	279.67	72.45
3.50	80.78	280.03	80.78
4.00	86.18	280.28	86.18
4.50	89.65	280.45	89.65
5.00	93.27	280.64	93.27
5.50	96.96	280.83	96.96
6.00	99.43	280.97	99.43
6.50	**100.76**	**281.05**	**100.76**
7.00	**100.75**	**281.04**	**100.75**
7.50	98.23	280.90	98.23
8.00	95.04	280.73	95.04
8.50	91.91	280.57	91.91
9.00	88.24	280.38	88.24
9.50	83.82	280.17	83.82
10.00	78.80	279.94	78.80
10.50	73.34	279.71	73.34
11.00	67.63	279.48	67.63
11.50	61.91	279.27	61.91
12.00	56.43	279.09	56.43
12.50	51.36	278.94	51.36
13.00	46.64	278.81	46.64
13.50	42.39	278.70	42.39
14.00	38.68	278.62	38.68
14.50	35.57	278.55	35.57
15.00	33.02	278.51	33.02
15.50	30.95	278.47	30.95
16.00	29.27	278.44	29.27
16.50	27.89	278.42	27.89
17.00	26.75	278.40	26.75
17.50	25.80	278.39	25.80
18.00	25.00	278.38	25.00
18.50	24.32	278.37	24.32
19.00	23.74	278.36	23.74
19.50	23.24	278.35	23.24
20.00	22.81	278.35	22.81
20.50	22.44	278.34	22.44
21.00	22.12	278.34	22.12
21.50	21.84	278.33	21.84
22.00	21.60	278.33	21.60
22.50	21.40	278.33	21.40
23.00	21.22	278.33	21.22
23.50	21.06	278.32	21.06
24.00	20.92	278.32	20.92
24.50	19.91	278.31	19.91
25.00	17.92	278.29	17.92
25.50	15.73	278.27	15.73

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
26.00	13.73	278.25	13.73
26.50	12.03	278.24	12.03
27.00	10.59	278.23	10.59
27.50	9.38	278.22	9.38
28.00	8.35	278.22	8.35
28.50	7.46	278.22	7.46
29.00	6.69	278.21	6.69
29.50	6.02	278.21	6.02
30.00	5.44	278.21	5.44
30.50	4.93	278.21	4.93
31.00	4.48	278.21	4.48
31.50	4.08	278.20	4.08
32.00	3.73	278.20	3.73
32.50	3.41	278.20	3.41
33.00	3.13	278.20	3.13
33.50	2.88	278.20	2.88
34.00	2.66	278.20	2.66
34.50	2.46	278.20	2.46
35.00	2.28	278.20	2.28
35.50	2.11	278.20	2.11
36.00	1.96	278.20	1.96

Stage-Discharge for Pond 3R: Outlet Pipe

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
253.00	0.00	268.60	0.00
253.30	0.00	268.90	0.00
253.60	0.00	269.20	0.00
253.90	0.00	269.50	0.00
254.20	0.00	269.80	0.00
254.50	0.00	270.10	0.00
254.80	0.00	270.40	0.00
255.10	0.00	270.70	0.00
255.40	0.00	271.00	0.00
255.70	0.00	271.30	0.00
256.00	0.00	271.60	0.00
256.30	0.00	271.90	0.00
256.60	0.00	272.20	0.00
256.90	0.00	272.50	0.00
257.20	0.00	272.80	0.00
257.50	0.00	273.10	0.00
257.80	0.00	273.40	0.00
258.10	0.00	273.70	0.00
258.40	0.00	274.00	0.00
258.70	0.00	274.30	0.00
259.00	0.00	274.60	0.00
259.30	0.00	274.90	0.00
259.60	0.00	275.20	0.00
259.90	0.00	275.50	0.00
260.20	0.00	275.80	0.00
260.50	0.00	276.10	0.00
260.80	0.00	276.40	0.00
261.10	0.00	276.70	0.00
261.40	0.00	277.00	0.00
261.70	0.00	277.30	0.00
262.00	0.00	277.60	0.00
262.30	0.00	277.90	0.00
262.60	0.00	278.20	0.00
262.90	0.00	278.50	32.72
263.20	0.00	278.80	46.27
263.50	0.00	279.10	56.67
263.80	0.00	279.40	65.43
264.10	0.00	279.70	73.16
264.40	0.00	280.00	80.14
264.70	0.00	280.30	86.56
265.00	0.00	280.60	92.54
265.30	0.00	280.90	**98.15**
265.60	0.00		
265.90	0.00		
266.20	0.00		
266.50	0.00		
266.80	0.00		
267.10	0.00		
267.40	0.00		
267.70	0.00		
268.00	0.00		
268.30	0.00		

Stage-Area-Storage for Pond 3R: Outlet Pipe

Elevation (feet)	Storage (cubic-feet)	Elevation (feet)	Storage (cubic-feet)
253.00	**0**	268.60	0
253.30	0	268.90	0
253.60	0	269.20	0
253.90	0	269.50	0
254.20	0	269.80	0
254.50	0	270.10	0
254.80	0	270.40	0
255.10	0	270.70	0
255.40	0	271.00	0
255.70	0	271.30	0
256.00	0	271.60	0
256.30	0	271.90	0
256.60	0	272.20	0
256.90	0	272.50	0
257.20	0	272.80	0
257.50	0	273.10	0
257.80	0	273.40	0
258.10	0	273.70	0
258.40	0	274.00	0
258.70	0	274.30	0
259.00	0	274.60	0
259.30	0	274.90	0
259.60	0	275.20	0
259.90	0	275.50	0
260.20	0	275.80	0
260.50	0	276.10	0
260.80	0	276.40	0
261.10	0	276.70	0
261.40	0	277.00	0
261.70	0	277.30	0
262.00	0	277.60	0
262.30	0	277.90	0
262.60	0	278.20	0
262.90	0	278.50	0
263.20	0	278.80	0
263.50	0	279.10	0
263.80	0	279.40	0
264.10	0	279.70	0
264.40	0	280.00	0
264.70	0	280.30	0
265.00	0	280.60	0
265.30	0	280.90	0
265.60	0		
265.90	0		
266.20	0		
266.50	0		
266.80	0		
267.10	0		
267.40	0		
267.70	0		
268.00	0		
268.30	0		

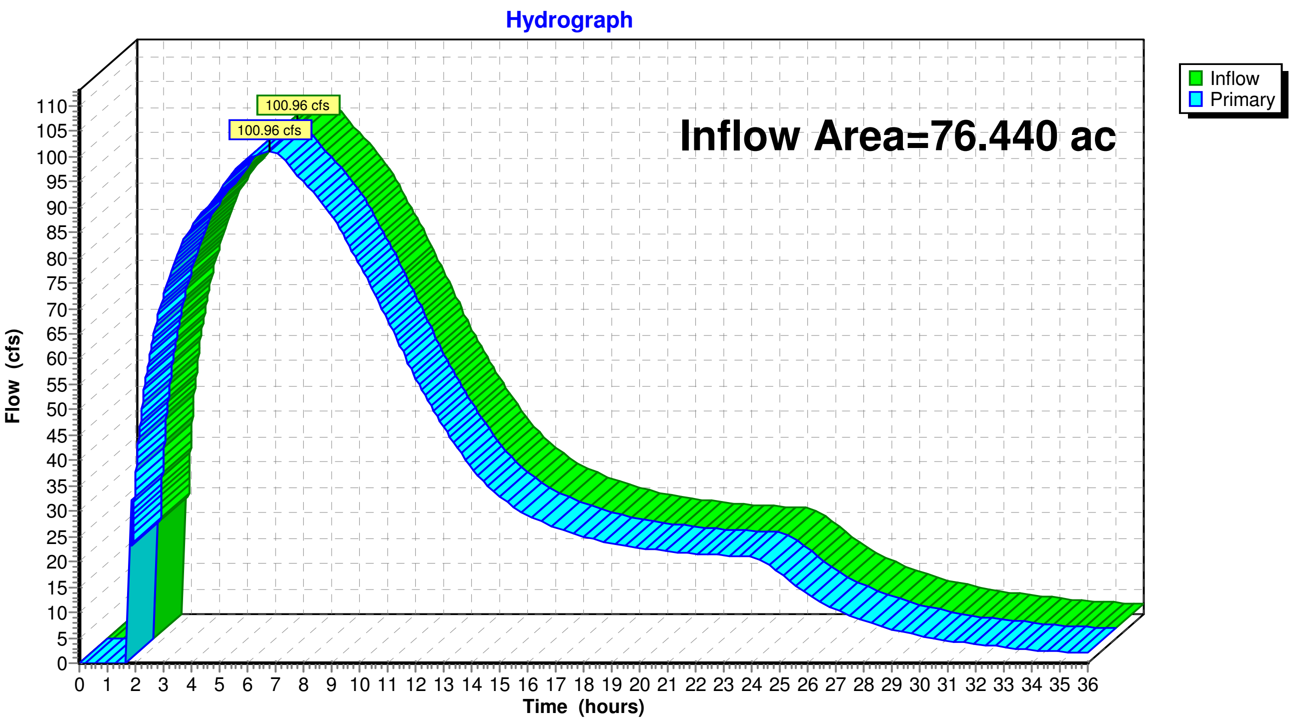
Summary for Link RIVER: River

Inflow Area =	76.440 ac,	19.10% Impervious,	Inflow Depth > 16.58"	for Half PMF event
Inflow =	100.96 cfs @	6.77 hrs, Volume=	105.608 af	
Primary =	100.96 cfs @	6.77 hrs, Volume=	105.608 af,	Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs

Fixed water surface Elevation= 278.20'

Link RIVER: River



Hydrograph for Link RIVER: River

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)	Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.01	**278.20**	0.01	26.00	13.73	278.20	13.73
0.50	0.00	278.20	0.00	26.50	12.03	278.20	12.03
1.00	0.00	278.20	0.00	27.00	10.59	278.20	10.59
1.50	0.00	278.20	0.00	27.50	9.38	278.20	9.38
2.00	35.49	278.20	35.49	28.00	8.35	278.20	8.35
2.50	60.28	278.20	60.28	28.50	7.46	278.20	7.46
3.00	72.45	278.20	72.45	29.00	6.69	278.20	6.69
3.50	80.78	278.20	80.78	29.50	6.02	278.20	6.02
4.00	86.18	278.20	86.18	30.00	5.44	278.20	5.44
4.50	89.65	278.20	89.65	30.50	4.93	278.20	4.93
5.00	93.27	278.20	93.27	31.00	4.48	278.20	4.48
5.50	96.96	278.20	96.96	31.50	4.08	278.20	4.08
6.00	99.43	278.20	99.43	32.00	3.73	278.20	3.73
6.50	**100.76**	278.20	**100.76**	32.50	3.41	278.20	3.41
7.00	**100.75**	278.20	**100.75**	33.00	3.13	278.20	3.13
7.50	98.23	278.20	98.23	33.50	2.88	278.20	2.88
8.00	95.04	278.20	95.04	34.00	2.66	278.20	2.66
8.50	91.91	278.20	91.91	34.50	2.46	278.20	2.46
9.00	88.24	278.20	88.24	35.00	2.28	278.20	2.28
9.50	83.82	278.20	83.82	35.50	2.11	278.20	2.11
10.00	78.80	278.20	78.80	36.00	1.96	278.20	1.96
10.50	73.34	278.20	73.34				
11.00	67.63	278.20	67.63				
11.50	61.91	278.20	61.91				
12.00	56.43	278.20	56.43				
12.50	51.36	278.20	51.36				
13.00	46.64	278.20	46.64				
13.50	42.39	278.20	42.39				
14.00	38.68	278.20	38.68				
14.50	35.57	278.20	35.57				
15.00	33.02	278.20	33.02				
15.50	30.95	278.20	30.95				
16.00	29.27	278.20	29.27				
16.50	27.89	278.20	27.89				
17.00	26.75	278.20	26.75				
17.50	25.80	278.20	25.80				
18.00	25.00	278.20	25.00				
18.50	24.32	278.20	24.32				
19.00	23.74	278.20	23.74				
19.50	23.24	278.20	23.24				
20.00	22.81	278.20	22.81				
20.50	22.44	278.20	22.44				
21.00	22.12	278.20	22.12				
21.50	21.84	278.20	21.84				
22.00	21.60	278.20	21.60				
22.50	21.40	278.20	21.40				
23.00	21.22	278.20	21.22				
23.50	21.06	278.20	21.06				
24.00	20.92	278.20	20.92				
24.50	19.91	278.20	19.91				
25.00	17.92	278.20	17.92				
25.50	15.73	278.20	15.73				

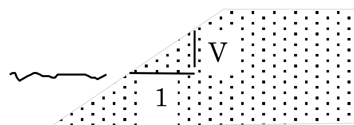
Analysis Procedure for determining the wind induced significant wave H_s and wave run-up using "Freeboard Criteria and Guidelines for Computing Freeboard Allowances for Storage Dams", USBR, 1981.

This procedure assumes that site specific wind data are not available, therefore, use the generalized fastest mile and 1-hour maximum winds from Figures 1 to 8 in above Reference. Use 80% of maximum winds for moderate wind condition during Maximum Flood condition.

Project Structures		**NA**	**NA**
Top Elevation w/o camber	290	NA	NA
Slope of u/s face (V >0.2 or 11.3°)	0.4	Vertical	Vertical
U/s Type of Surface	Soil Cement	Concrete	Concrete
General Direction Orientation			

Normal Reservoir Elev. (ft)	286	Assume maximum wind
Maximum Flood Elev. (ft)	288.5	Assume Moderate wind
	-06-1609.00-001	

Effective Fetch	***Normal***	***Flood***
F_e from Trial and Error (miles)	0.13	0.13
Wind correction Water/Land based on Table 2 & F_e	1.043	1.043



Where: Wind velocity Ratio Land/Water = $1.0301 + 0.098184F_e + 0.0079048F_e^2 - 0.0076136F_e^3 + 0.00085282F_e^4$ with a maximum of 1.30

Meteorological Data

	Figure	**Value from Graph (mph)**	**Normal Pool over water (mph)**	**Max Flood Pool over water (mph)**
Fastest Mile from Figures 1-4 (1 minute)		62	65	52
Season of the year:	Spring			
Fastest Mile from Figures 5-8 (1 hour)		40	42	33
Season of the year:	Summer			
Fastest Mile (2 hour) = 0.96 x (1 hour)		38	40	32

Wind Velocity and Duration Data Points from Figure 9

Fetch N	Fetch F
0.133	0.133

Wind (mph)@ 25' above the water for duration (minutes)

Interpolate Wind velocity values for Normal Pool and Max. Flood Pool from Figure 9 using the appropriate Fetch.

Find at least 5 points and bracket wind velocities found in table above using Figures 1-8.

Values will be used to plot Wind Velocity over Water vs Duration.

See Plots of Normal & Flood

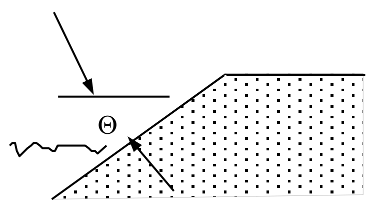
Duration (min)	Normal Pool over water (mph)	Max Flood Pool over water (mph)
1.0	80.0	80.0
4.0	48.0	48.0
5.0	28.0	28.0
6.0	18.0	18.0
7.0	13.0	13.0
8.0		
9.0		
10.0		
15.0		
20.0		
25.0		
30.0		
40.0		
50.0		
60.0		
70.0		
80.0		
90.0		
100.0		
120.0		
140.0		
160.0		
180.0		
200.0		

	Normal	Flood
From Figure 9, determine the significant wave height H_s =	1.1	0.85
From USBR page 15, for Normal Freeboard, Modify H_s to account for average of highest 10% of waves = 1.27 x H_s =	1.4	

Calculate Wave Runup and Wave Setup

	Normal		Flood
From USBR Fig. 10, Determine the	1.7	seconds	1.55
From USBR Eq. 2, the wave length L =	14.8	feet	12.3
L = 5.12 * T^2 assumes deep water conditions where the reservoir depth is greater than 1/2 L =	7.4	feet	6.2

	Earth Dam
Average Pool depth, D @ Central Radial (ft)	26
Is D > L/2 to ignore bottom effects?	*YES*
U/s surface slope	0.4
Angle (deg) of u/s face of dam with the horizon Θ > 11.3°	21.80
Cot Θ =	2.50



OK

Eq. 3 Runup for Significant Wave Height " Rs " (ft)

	Normal	Flood
Riprap	1.4	1.0
Correction for Angle Offset if direction of wave propagation is not normal to the embankment	1.4	1.0

Angle (degrees) (1<α<50)	1
Smooth Face Correction Factor	1.2

From USBR pg. 13, Earth dam w/ smooth face. (Factor <1.5)

Not a Rockfill Dam

Eq. 4 Wind Setup " S " (ft) For:

From Plotted graph of Wind Velocity over water vs Duration	**Velocity (mph)**	**Duration (minutes)**
Normal Pool	64.1014438	2.49048964
Flood Pool	50.8958757	3.72851166

Normal Pool

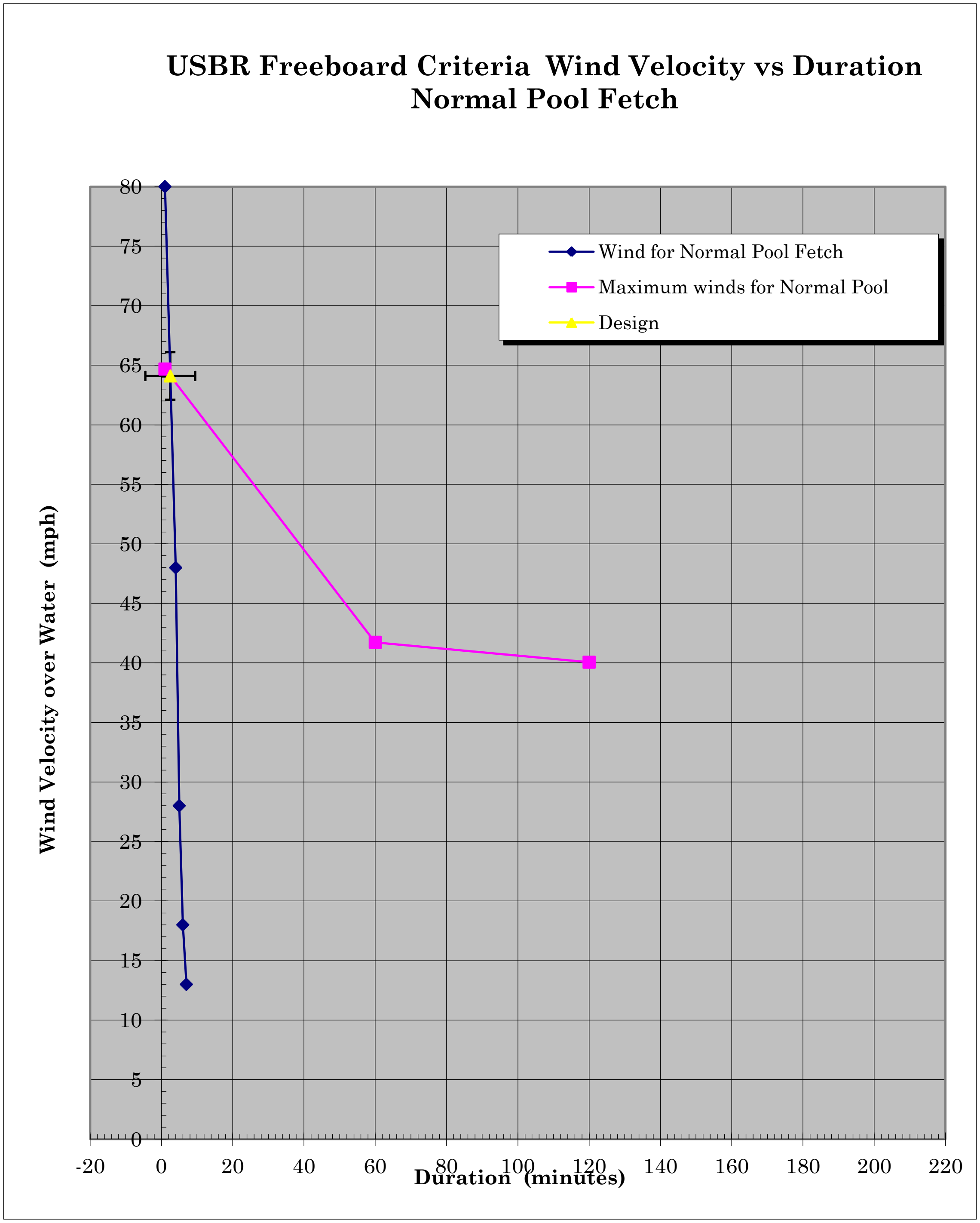
Setup = **0.03** feet

Flood Pool

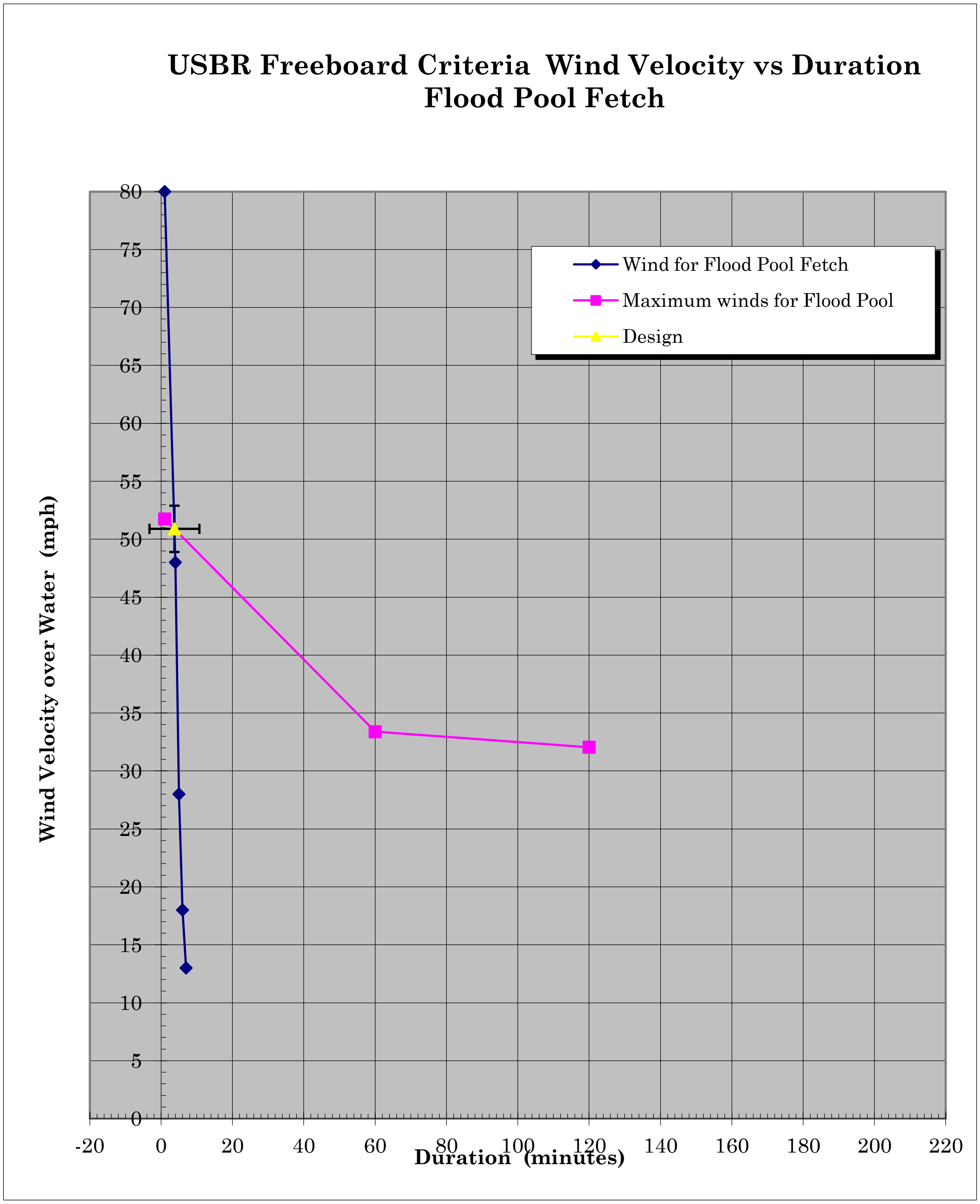
Setup = **0.02** feet

Minimum Freeboard Requirement (feet)

	Earth Dam
Normal Pool	**1.46**
Req'd Design Dam Crest Elevation	**287.5**
Required < Available ?	OK
Flood Pool	**0.98**
Req'd Design Dam Crest Elevation	**289.5**
Required < Available ?	OK



USBR Freeboard Criteria Wind Velocity vs Duration
Normal Pool Fetch
Wind Velocity over Water (mph)
Duration (minutes)
Wind for Normal Pool Fetch
Maximum winds for Normal Pool
Design
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
-20
0
20
40
60
80
100
120
140
160
180
200
220


USBR Freeboard Criteria Wind Velocity vs Duration
Flood Pool Fetch
Wind Velocity over Water (mph)
Duration (minutes)
Wind for Flood Pool Fetch
Maximum winds for Flood Pool
Design
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
-20
0
20
40
60
80
100
120
140
160
180
200
220

Calculate the effective fetch, Fe, from existing topographic map of project. Construct a central radial and 7 radial lines at 6 degree intervals on each side. Draw the central radial from a point on the face of the dam to a point on the opposite shoreline in the direction to yield the longest distance over open water.

Radial Number	Angle α	Cos α	$\text{Cos}^2\ \alpha$	X_i scale distance (ft)	$\text{Cos}^2\ \alpha * X_i$
1	42	0.7431	0.5523	781	431.32
2	36	0.8090	0.6545	779	509.86
3	30	0.8660	0.7500	785	588.75
4	24	0.9135	0.8346	799	666.82
5	18	0.9511	0.9045	823	744.41
6	12	0.9781	0.9568	859	821.87
7	6	0.9945	0.9891	907	897.09
8	0	1.0000	1.0000	971	971.00
9	6	0.9945	0.9891	920	909.95
10	12	0.9781	0.9568	975	932.85
11	18	0.9511	0.9045	841	760.69
12	24	0.9135	0.8346	816	681.01
13	30	0.8660	0.7500	478	358.50
14	36	0.8090	0.6545	191	125.01
15	42	0.7431	0.5523	116	64.06
	Σ	13.5109	Σ	11041	9463.19

Effective Fetch (F_e) = 700.41 ft.

Trial 1 or **0.13** miles

Check (F_e) = 0.14 miles

Calculate the effective fetch, Fe, from existing topographic map of project. Construct a central radial and 7 radial lines at 6 degree intervals on each side. Draw the central radial from a point on the face of the dam to a point on the opposite shoreline in the direction to yield the longest distance over open water.

Radial Number	Angle α	Cos α	$Cos^2 \alpha$	X_i scale distance (ft)	$Cos^2 \alpha * X_i$
1	42	0.7431	0.5523	781	431.32
2	36	0.8090	0.6545	779	509.86
3	30	0.8660	0.7500	785	588.75
4	24	0.9135	0.8346	799	666.82
5	18	0.9511	0.9045	823	744.41
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7	6	0.9945	0.9891	907	897.09
8	0	1.0000	1.0000	971	971.00
9	6	0.9945	0.9891	920	909.95
10	12	0.9781	0.9568	975	932.85
11	18	0.9511	0.9045	841	760.69
12	24	0.9135	0.8346	816	681.01
13	30	0.8660	0.7500	478	358.50
14	36	0.8090	0.6545	191	125.01
15	42	0.7431	0.5523	116	64.06
	Σ	13.5109	Σ	11041	9463.19

700.41 ft.

Trial 2 or **0.13** miles

0.14 miles

October 30, 2012 390/181182

MEMORANDUM

TO: Benjamin Wilburn, E.I.T./PPL

FROM: Adam Jones, P.E.

SUBJECT: **Brunner Island Ash Basin No. 6**
Piping Assessment

This memo summarizes HDR's assessment of seepage and seepage gradients within the embankment at Brunner Island Ash Basin No. 6. This work is being performed in response to comments from the United States Environmental Protection Agency (USEPA) and their contractor, GZA GeoEnvironmental, Inc. (GZA) presented in emails dated October 18 and October 19, 2012.

From the USEPA Email dated October 18, 2012

One final look at the PPL Brunner Island Final Report left us with an open issue that should have been discussed previously, however, yet still needs to be addressed before the final report is approved. The issue surrounds the parts in the report (page ii of the Executive Summary and page 13, section 2.6) that address the following:

From page ii of the Executive Summary

> *"Studies and Analyses:*
> *1. The Seepage analyses data presented in the hard copy of the February 17, 2012 Geotechnical Engineering Report prepared by Schnabel Engineering recently provided for GZA review did not include calculated factors of safety. It is recommended that the Schnabel report be amended to include results of the seepage analyses and that factors of safety therefrom be compared with accepted minimums. If said factors of safety are found to be below accepted minimums, remediation of the embankments would be warranted."*
>
> *And*
>
> *"Remedial Measures:*
>
> *2. If the results of additional stability analyses (recommended above) continue to indicate inadequate factors of safety or in the absence of additional stability analyses, take the necessary actions required to remediate the embankment such that adequate factors of safety are met."*
>
> *From page 13, section 2.6*
> *"Seepage is controlled by a 10 foot thick clay liner at the inside face of the embankment from elevation 287.5 feet to bedrock. The Seepage analyses data presented in the hard copy of the*

Schnabel report provided for GZA review did not include calculated factors of safety. It is recommended that the Schnabel report be amended to include results of the seepage analyses and that factors of safety therefrom be compared with accepted minimums. GZA did not perform an independent assessment of the seepage stability of the basins as this was beyond our scope of services."

GZA needs to make the call as to whether the documentation that PPL's contractor submitted is acceptable or not.

From the GZA email dated October 19, 2012

GZA takes the critical gradient as 1.0, as is typically done for sands; thus, the safety factor against potential piping failure is computed as:

$$F.S._{piping} = i_{cr} / i_{exit}$$

The US Army Corps of Engineers document Seepage Analysis and Control for Dams – EM 1110-2-1901 dated 30 September 1986 refers to typically accepted recommended factor of safety against seepage failure are 4 to 5 (Harr, 1962, 1977) or 2.5 to 3.0 (Cedergren, 1977).

However another reference has the factor of safety from 4 to 6 (Holtz and Kovacs, 1981).

Again, I believe your geotechnical consultant probable already has the seepage computations for the most severe condition, which is likely when the basin pool is full and the tailwater from the river is low.

Previous Analyses

HDR performed slope stability analyses of the Brunner Island Ash Basin 6 embankment, summarized in the *Slope Stability Assessment Report*, dated December, 2009 (HDR, 2009). These analyses, which included a limited geotechnical exploration, evaluated the stability of the downstream face of the embankment for the normal operating, surcharge pool, seismic, and rapid drawdown conditions. The rapid drawdown analyses assumed that the downstream slope was fully saturated as a result of flooding on the Susquehanna River, and that no drainage of the slope occurred during recession of the river following a flood event. Piezometer measurements were used to establish the phreatic surfaces assumed in the stability analysis, and no seepage analyses were conducted.

A transient seepage analysis followed by a rapid drawdown analysis was performed by Schnabel Engineering Consultants, Inc., (Schnabel) and is summarized in their *Geotechnical Engineering Report, Brunner Island SES Transient Seepage and Slope Stability Study* (Schnabel, 2012). This study determined that factors of safety for the rapid drawdown condition were adequate, even for extreme floods. While this study included steady state and transient seepage analyses, Schnabel noted that the analyses did not include an assessment of seepage gradients.

Note that both of the above engineering assessments were intended to address specific concerns; the stability of the downstream slope of the eastern section of the embankment, and the stability of the embankment under rapid drawdown conditions in particular.

Seepage Conditions

HDR shares the concerns of EPA and their contractor, GZA, with regard to the seepage and piping. Piping, or internal erosion as described below, is a primary cause of embankment failures, and seepage through any embankment that is not constructed with modern filters is a condition that must be considered carefully. That said, there are a number of embankment dams that experience seepage which have been successfully maintained by careful monitoring, investigation, and remedial action where warranted.

As noted in HDR, 2009, seepage conditions at Brunner Island are not straightforward. Two embankment sections were considered for analysis with respect to slope stability, as shown on Figure 1. The section at Station 7+44 was selected based on the seepage that was evident at the time, which, while nearly imperceptible with respect to flow, was daylighting on the slope, most recently about 8 feet above the toe during HDR's June, 2012 inspection. While seepage flows did not appear significant enough to move particles, and there was no evidence of boils, turbidity, or material transport, the location of the seepage raised the concern that the phreatic surface could be elevated, which would adversely affect slope stability. The section at Station 7+44 is at a section of the embankment which has open water at the upstream face, therefore, piping in this area, if it were to occur, would have the potential to connect to the reservoir, which would likely lead to a significant breach. The second section that was selected was at Station 21+80, adjacent to an area where surface sloughing had occurred following drawdown of the Susquehanna River after a flood, which had raised the stability concerns initially. This section also offered the ability to calibrate slope stability models to a known factor of safety of approximately 1.0 for a shallow sloughing surface under drawdown conditions. Seepage flow was not visible, although the toe was wet. While the basin was filled with ash in this area, there was a channel carrying plant process water adjacent to the upstream face that would have the potential to cause a progressive failure if a piping path connected to it. A third seepage area was observed at the northwest corner of the ash basin. Here seepage flow was visible at and slightly above the toe. The seepage was clear, there was no evidence of boils or material transport, and there were no quick conditions observed. This section of the ash basin also has been filled, and the nearest free water source is several hundred feet away, thus it appears that there is limited potential for retrogressive piping to result in an uncontrolled breach.

Variations in the phreatic surface were observed between the two cross sections in which piezometers were installed, as seen on Figures 2 and 3. It was apparent that the observed seepage at Station 7+44 was the result of an isolated permeable zone that was not reflected by the piezometers, or by capillarity or some other cause. The embankments were constructed with an upstream clay liner, and the effect of the liner on embankment seepage and phreatic levels is not clear, since the relative permeability between the liner and the embankment fill varies at different sections and depths. The attached Seep models demonstrate anticipated flow lines and seepage gradients where the liner is significantly more impermeable than the embankment fill, and where their permeabilities are more similar.

Seepage and Piping Assessment

There are 5 separate failure modes of embankments that are attributed to seepage and piping (United States Bureau of Reclamation, *Internal Erosion and Piping Risks for Embankments*, 2010.)

1. "Heave" can occur where an impervious layer overlies more pervious material near the downstream toe of a dam.
2. Classical "piping" occurs when soil erosion begins at a seepage exit point, and erodes backwards, supporting a "pipe" or "roof" along the way.
3. "Progressive erosion" can occur when the soil is not capable of sustaining a roof or a pipe. Soil particles are eroded and a temporary void grows until a roof can no longer be supported, at which time the void collapses. This mechanism is repeated progressively until the core is breached or the downstream slope is over-steepened to the point of instability.
4. "Scour" occurs when tractive seepage forces along a surface (i.e. a crack within the soil, adjacent to a wall or conduit, or along the dam foundation contact) are sufficient to move soil particles into an unprotected area. Once this begins, a process similar to piping or seepage erosion could result.
5. "Internal instability" occurs when the finer particles of a soil are eroded through the coarser fraction of that soil, leaving behind a coarsened and more permeable soil skeleton. The loss of material can lead to voids and sink holes.

The assessment of each of these piping modes as they relate to the embankment at Brunner Island is discussed below:

Heave

Of the potential failure modes discussed above, heave is the only mode that readily lends itself to analysis through the use of seepage gradients. The vertical seepage gradients at both sections are relatively low, between 0 and 0.2, which corresponds to a factor of safety of between 5 and 10, assuming a cohesionless soil. This is well within the recommended values of 2 to 2.5 recommended by Cedergren (*Seepage, Drainage and Flow Nets*, 1989,) and within the range of 4 to 6 recommended by Harr, the Corps of Engineers (*EM1110-2-1901 Seepage Analysis and Control for Dams*, 1993,) and Holtz and Kovacs (*Geotechnical Engineering*, 1981.) Failure by heave is not an anticipated failure mode for a moderately impermeable embankment on a moderately impermeable foundation.

<u>*Classical Piping, Progressive Erosion and Scour*</u>

Classical piping is a potentially viable failure mode at Brunner Island, since seepage is exiting the downstream face that is not filtered. Localized gradients at the toe were calculated at approximately 0.4, which are significant. Unlike heave, however, there is no analytic method, or basis for calculation of a factor of safety with respect to classical piping. As noted by Terzaghi and Peck, (*Soil Mechanics in Engineering Practice*, 1967) "The factor of safety with respect to piping by subsurface erosion cannot be evaluated by any practicable means". The same argument applies to progressive erosion. FEMA, in *Filters for Embankment Dams Best Practices for Design and Construction, 2011* notes that material type has as much impact on particle erosion as gradient, and further notes that plastic clay is highly erosion resistant. With respect to scour, observed velocities for the seepage at the east embankment are very low, and it is not anticipated that particle movement is a significant likelihood.

<u>*Internal Instability*</u>

Internal instability could be a viable potential failure mode, at the interface between the clay liner and the random embankment fill. The gradients in this area could be in the order of 5 feet per foot, which is not unusual at the interface between an impermeable core and downstream soil. As noted by Cedergren, with properly designed filters, there is "no harm in designing a dam with high internal gradients, but a design with high seepage gradients should offer substantial benefits to warrant consideration." Although the embankment has been in successful operation for over 30 years with no evidence of piping, a significant engineering limitation with respect to the evaluation of internal instability is the lack of the relative gradation information and dispersivity testing that is needed to evaluate filter compatibility. This is a problem that is common to a large number of dams that were constructed prior to the understanding of modern seepage criteria.

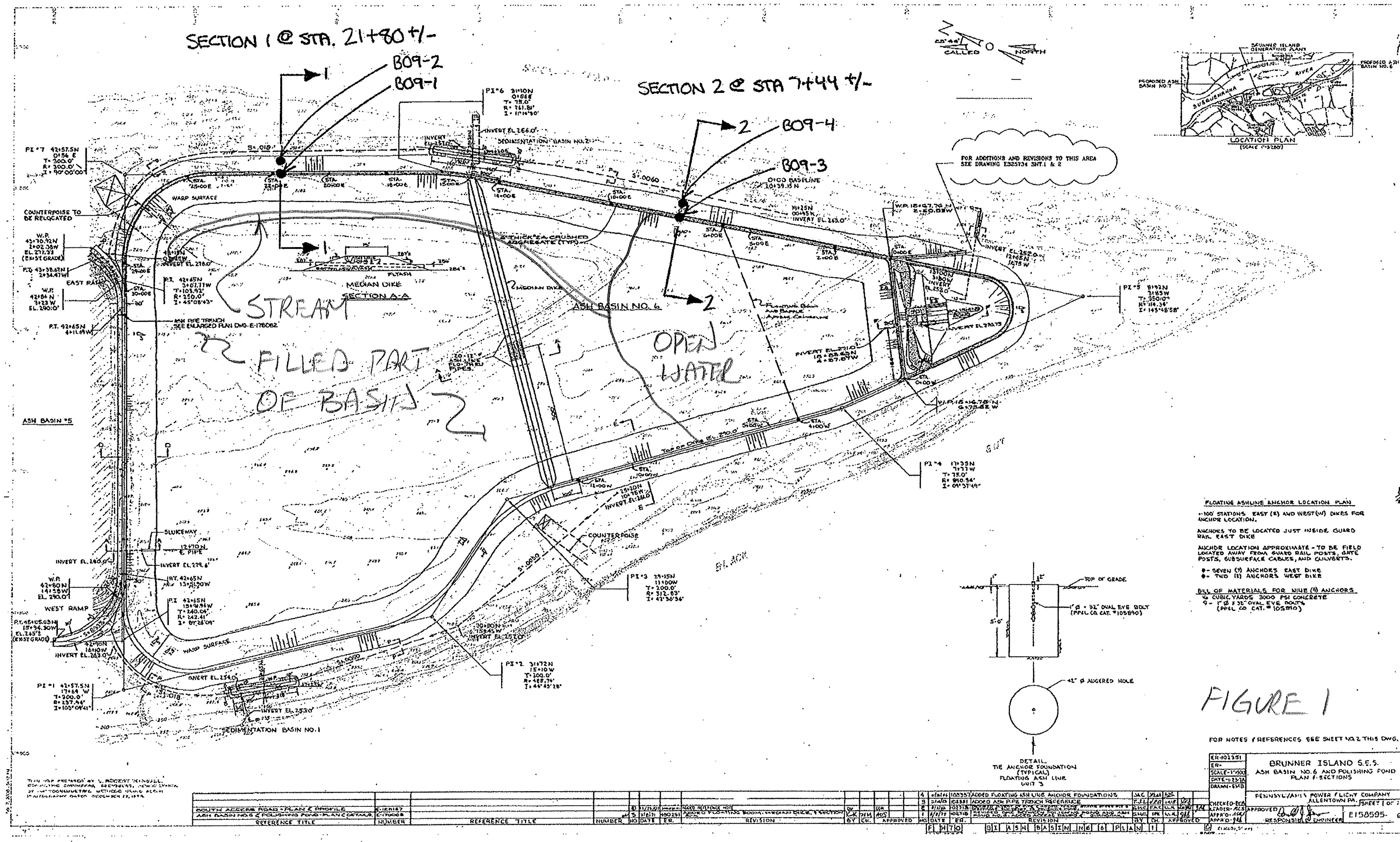
Conclusions and Recommendations

Seepage is a significant dam safety concern, and our recommendations with respect to seepage at Brunner have been, and continue to be, assessment based on visual observations, prudent monitoring, and a conservative long-term plan.

While the seepage at Brunner Island does not appear to be of immediate concern, the safest and most practical alternative to address the seepage concerns is to close the basin as soon as practicable, as proposed by PPL. Seepage should diminish considerably when the basin is closed and the reservoir lowered, as this has occurred at other basins following closure. If seepage is still observed as a result of rainwater infiltration or other causes, it is unlikely that it would result in a piping failure, but should be addressed in the closure plan. Until that time, it is prudent to monitor the embankment seepage and to be prepared to mitigate seepage should piping be observed, steps that are consistent with normal dam safety practice. In particular, surface sloughs should be repaired immediately should they occur, preferably with a filter compatible material. Extension of the effluent discharge lines across the filled part of the basin, so that they discharge directly into the open pond, would offer a short term but significant means of reducing risk associated with the northern half of the ash basin.

Seepage that results in boils, quick conditions, soil transport, or turbidity which would indicate piping is not acceptable. Also, any changes in seepage, including sudden or progressive increases in flow, pressure or location would be a concern, particularly if there is turbidity or other evidence of material transport. These conditions, were they to be observed, would warrant immediate action, which could include construction of filters, drains, seepage barriers, lowering the reservoir, or a combination of those measures. None of these conditions has been observed however, and these precautions should be considered applicable to all dams that do not have seepage filters, not just Brunner Island.

Attachments



PPL/BRUNNER ISLAND
GEOTECHNICAL EXPLORATION
BORING PLAN (REVISED)
5/28/09

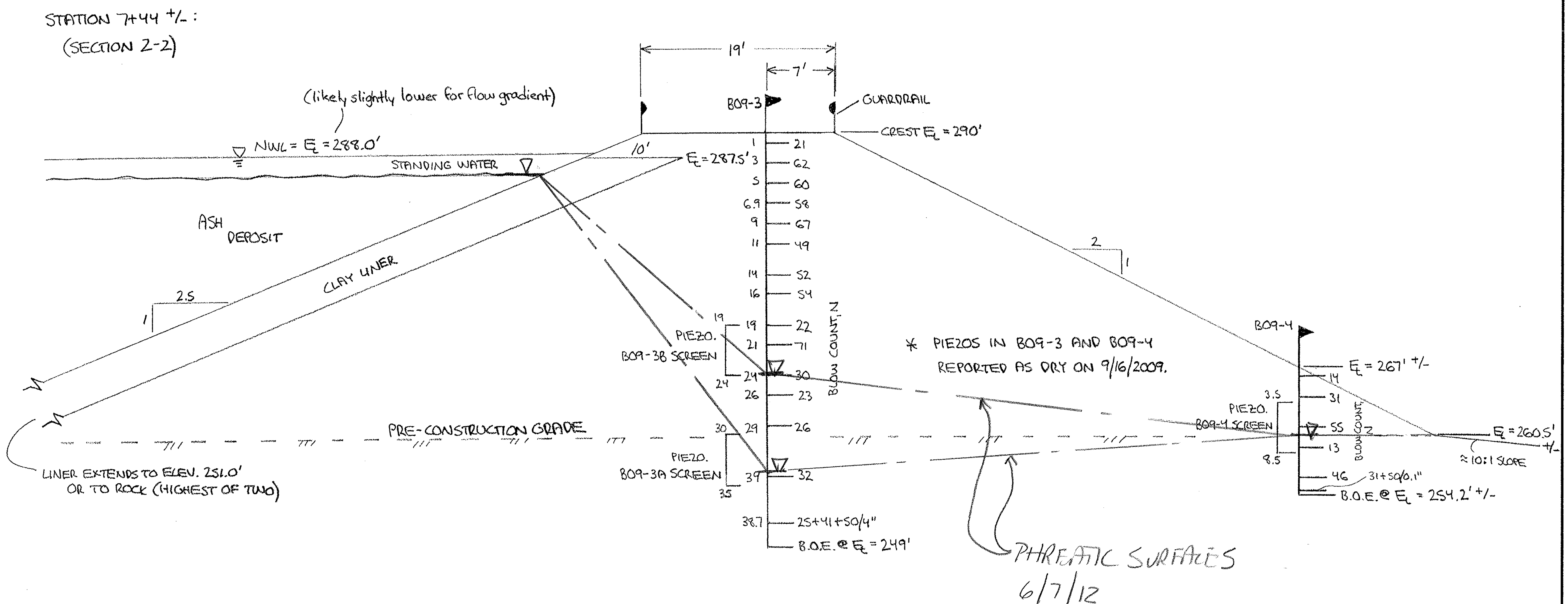
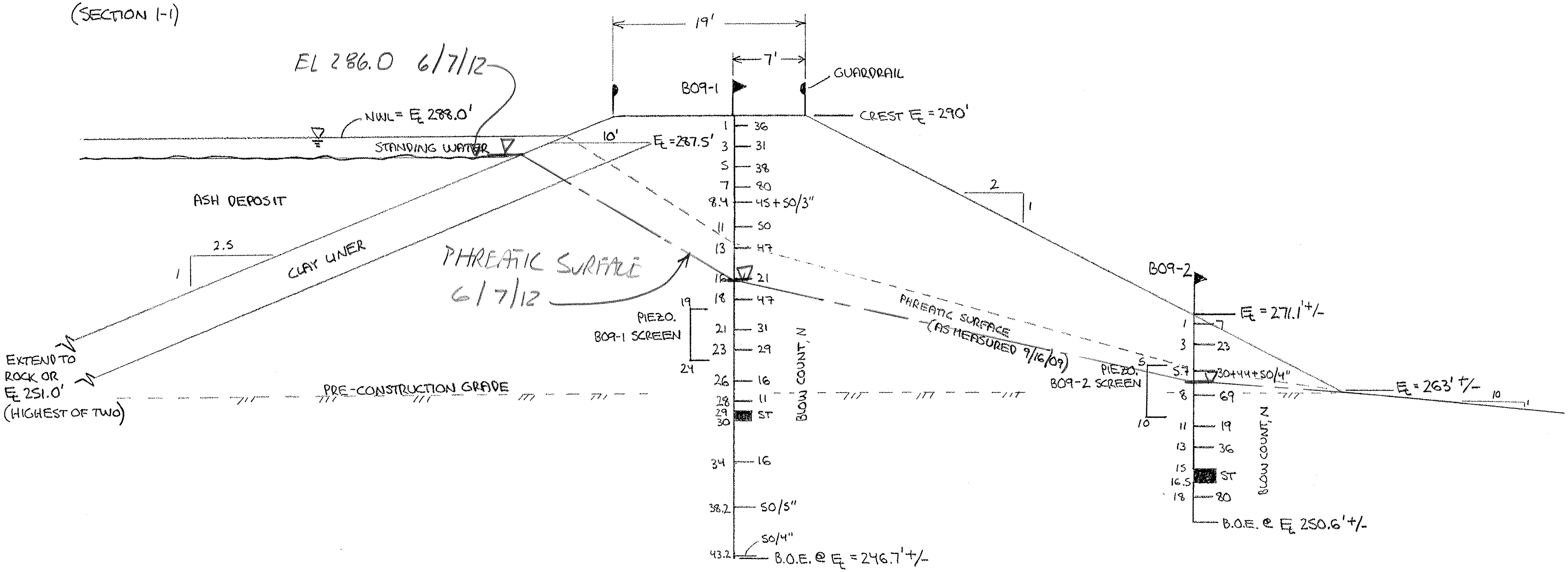


FIGURE 2

						JOB NO	PAGE 2
	NBS	9/23/09				CALC NO	OF 2
REV	BY	DATE	CHECKED	DATE			

STATION 21+80 +/- :
(SECTION 1-1)



* NOTE: "ST" = SHELBY TUBE

FIGURE 3

					BRUNNER ISLAND AB 6 - STATION 21+80
					JOB NO
	NBS	9/23/09			CALC NO
REV	BY	DATE	CHECKED	DATE	PAGE 1 OF 2

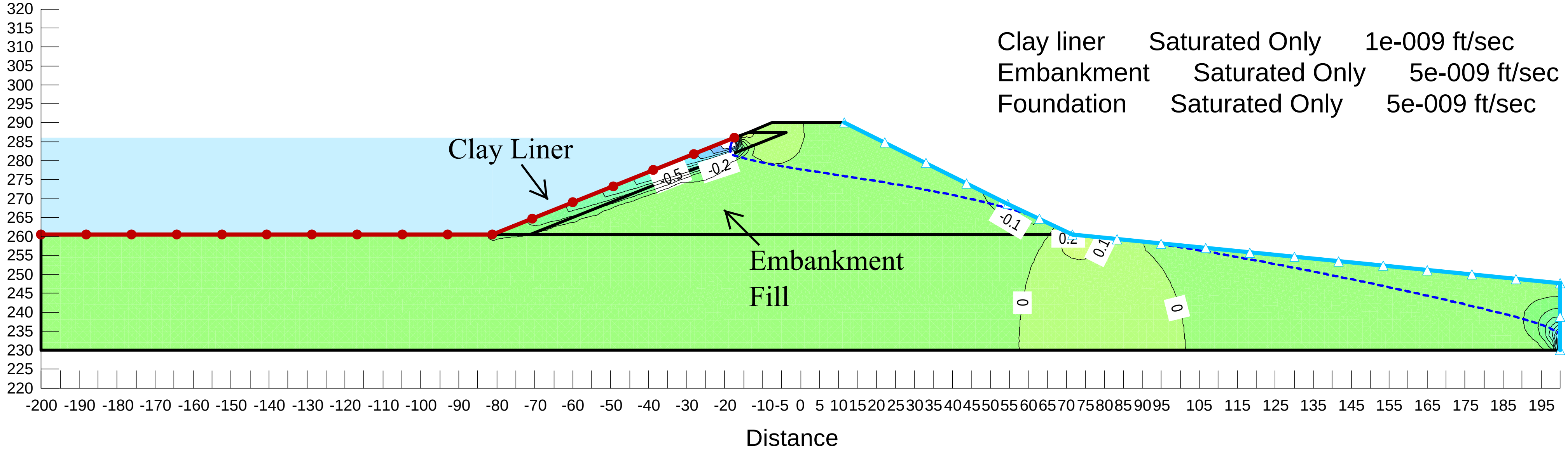


Figure 4
Clay Liner and Embankment Fill with
Similar Permeability
Vertical Seepage Gradient Plotted

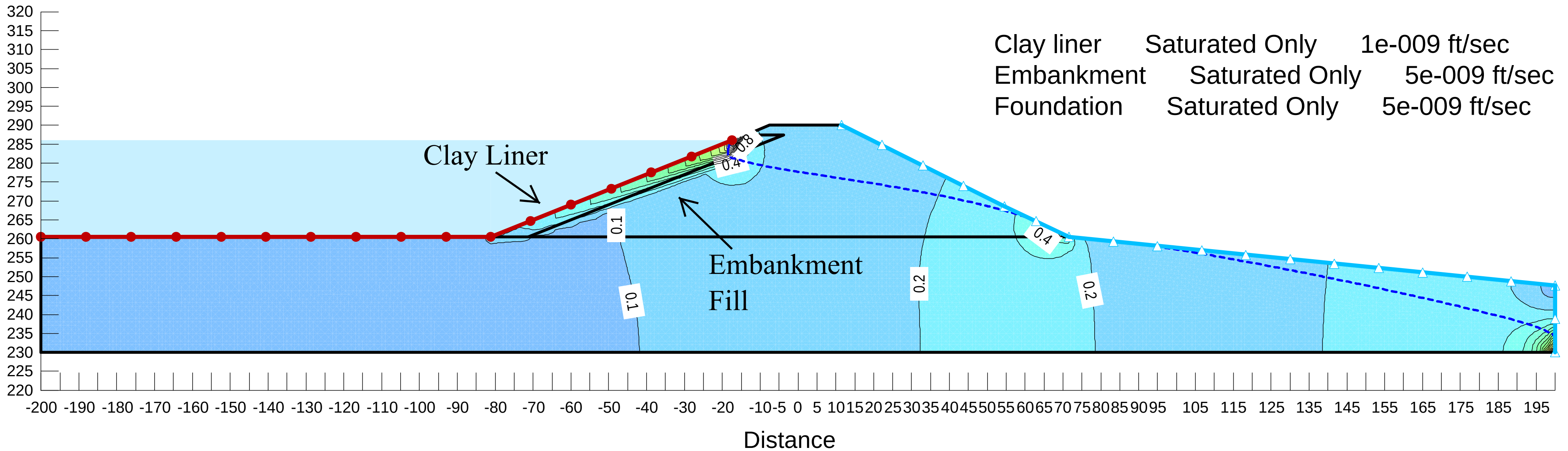


Figure 5
Clay Liner and Embankment Fill with
Similar Permeability
X-Y Seepage Gradient Plotted

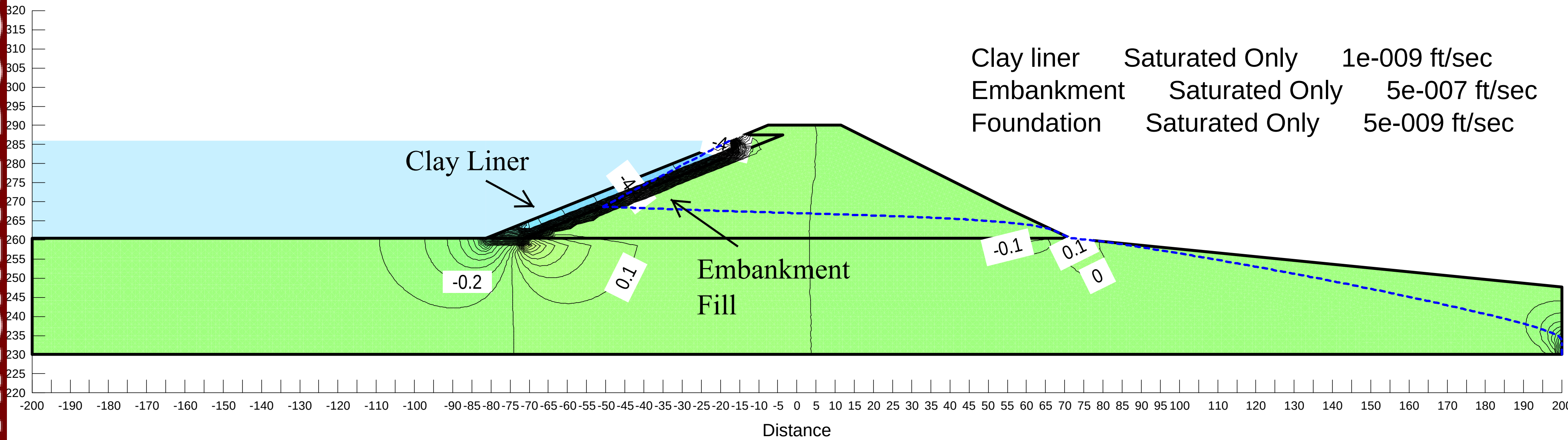


Figure 6
Clay Liner Permeability << Embankment Fill Permeability
Vertical Seepage Gradient Plotted

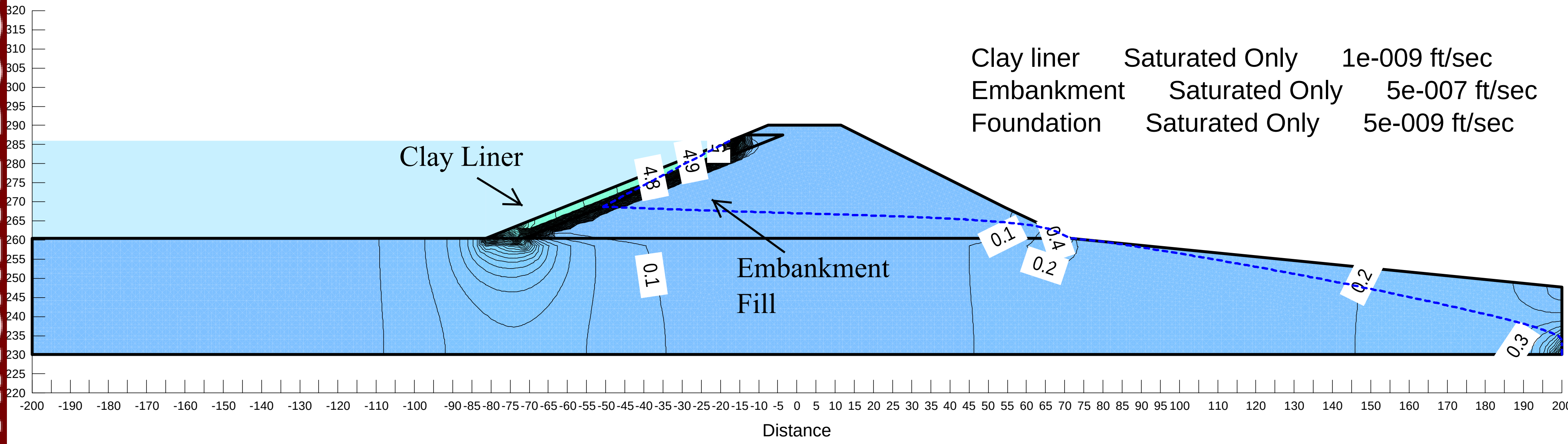
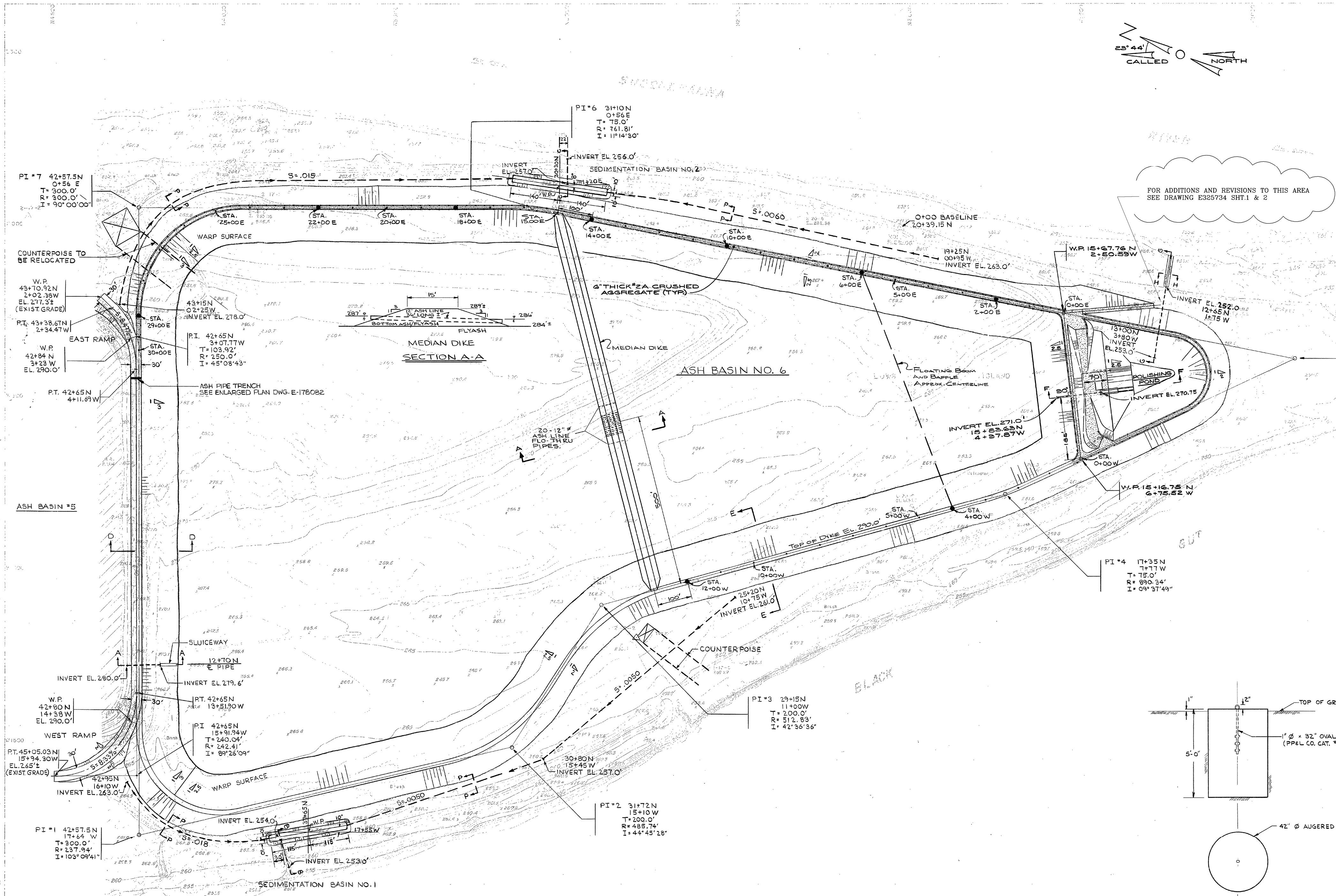
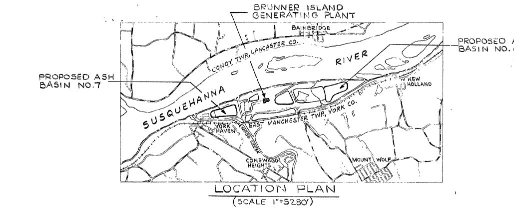


Figure 7
Clay Liner Permeability << Embankment Fill Permeability
X-Y Seepage Gradient Plotted

APPENDIX F

SELECTED RECORD INFORMATION





LOCATION PLAN
(SCALE 1"=5280')

FLOATING ASHLINE ANCHOR LOCATION PLAN

•-100' STATIONS EAST (E) AND WEST (W) DIKES FOR ANCHOR LOCATION.

ANCHORS TO BE LOCATED JUST INSIDE GUARD RAIL EAST DIKE

ANCHOR LOCATION APPROXIMATE - TO BE FIELD LOCATED AWAY FROM GUARD RAIL POSTS, GATE POSTS, SUBSURFACE CABLES, AND CULVERTS.

●- SEVEN (7) ANCHORS EAST DIKE
●- TWO (2) ANCHORS WEST DIKE

BILL OF MATERIALS FOR NINE (9) ANCHORS

16 CUBIC YARDS 3000 PSI CONCRETE
9 - 1" Ø X 32" OVAL EYE BOLTS (PP&L CO. CAT. # 105890)

TOP OF GRADE
1" Ø x 32" OVAL EYE BOLT (PP&L CO. CAT. #105890)
5'-0"
42" Ø AUGERED HOLE

DETAIL
TIE ANCHOR FOUNDATION
(TYPICAL)
FLOATING ASH LINE
UNIT 3

FOR NOTES & REFERENCES SEE SHEET NO. 2 THIS DWG.

THIS MAP PREPARED BY L. ROBERT KIMBALL, CONSULTING ENGINEERS, EBENSBURG, PENNSYLVANIA, BY PHOTOGRAMMETRIC METHODS USING AERIAL PHOTOGRAPHY DATED DECEMBER 22, 1975.

REFERENCE TITLE	NUMBER
SOUTH ACCESS ROAD - PLAN & PROFILE	E-159157
ASH BASIN NO. 6 & POLISHING POND - PLAN & DETAILS	E-178085

NO.	DATE	ER.	REVISION	BY	CH.	APPROVED
6	11/26/07	37003158-01	ADDED REFERENCE NOTE	DM		GDH
5	2/8/91	480251	ADDED FLOATING BOOM, MEDIAN DIKE, & SECTION A-A	KWK	DEM	ADS
4	11/28/86	103357	ADDED FLOATING ASH LINE ANCHOR FOUNDATIONS	JAC	Hash	ADS
3	2/10/83	102351	ADDED ASH PIPE TRENCH REFERENCE	T.J.L.	H.R.D.	WJB JAS
2	4/2/80	102713	REVISED INVERT OF PIPE & ADDED IN-LINE STATIC MIXER PIT & DISCHARGE SLUICEWAY TO POLISHING POND.	G.H.C.	FAC	A.L.M. WJB JAS JAS
1	6/8/79	102713	REVISED DIKE BETWEEN POLISHING POND AND ASH POND NO. 6. ADDED ACCESS RAMPS & GUARDRAIL.	G.H.C.	DPK	A.L.M. JAS

ER-102351
ER-
SCALE-1"=100'
DATE-1-23-78
DRAWN-EMB
CHECKED-RCB
LEADER-RCS
APPR'D-NHJ
APPR'D-JAS

BRUNNER ISLAND S.E.S.
ASH BASIN NO. 6 AND POLISHING POND
PLAN & SECTIONS

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN PA.

SHEET 1 OF 2

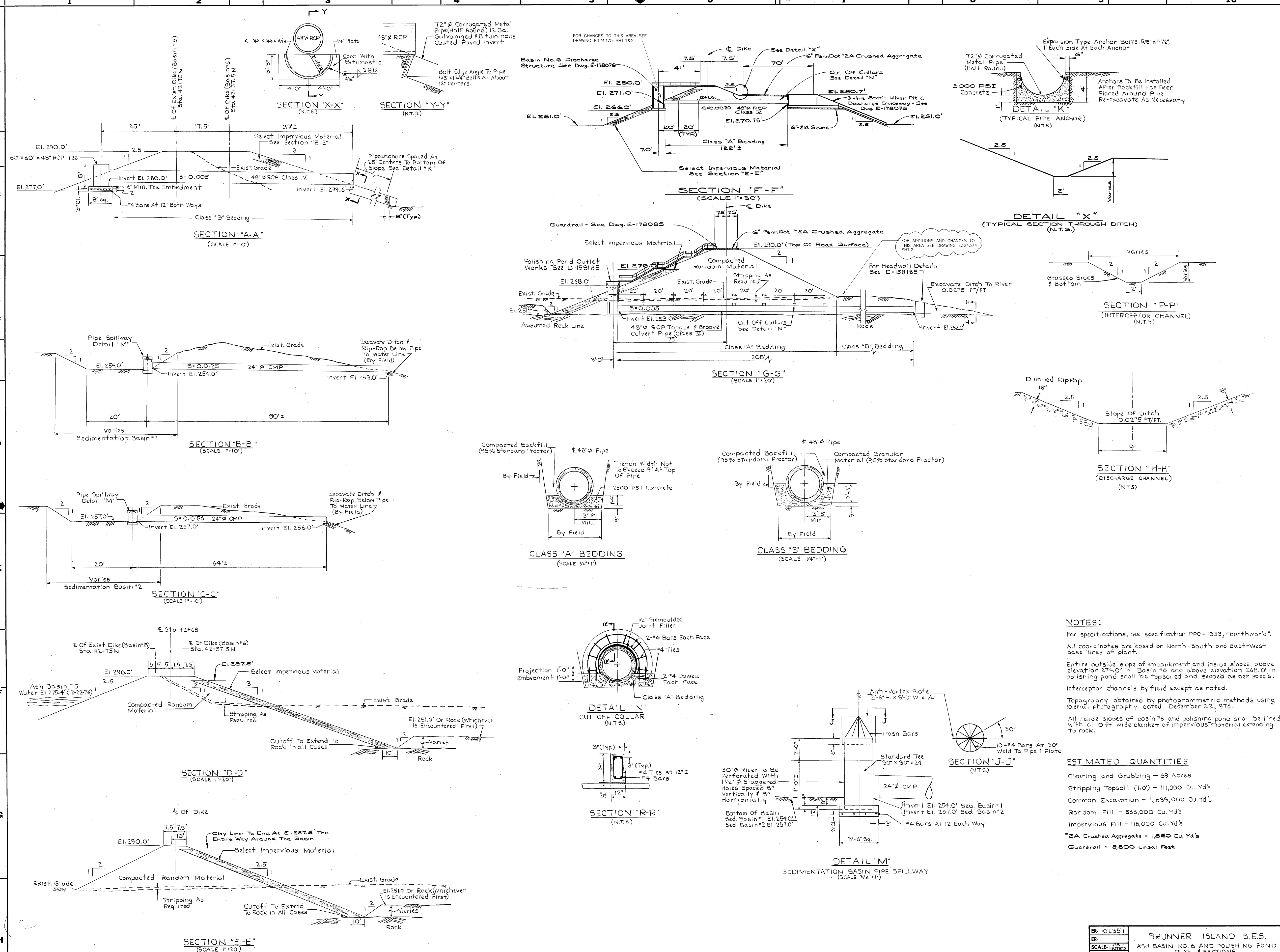
APPROVED Donald J. [signature]
RESPONSIBLE ENGINEER

E158595- 6

F H70 BI ASH BASIN NO 6 PLAN 1 C

E158595_S1.dwg

Feb. 7, 2008 - 9:12 AM



NOTES:

For specifications, see specification PPC-1333, "Earthwork".

All coordinates are based on North-South and East-West base lines of plant.

Entire outside slope of embankment and inside slopes above elevation 274.0' in Basin #6 and above elevation 268.0' in polishing pond shall be topsoiled and seeded as per spec's.

Interceptor channels by field except as noted.

Topography obtained by photogrammetric methods using aerial photography dated December 22, 1976.

All inside slopes of basin #6 and polishing pond shall be lined with a 10 ft. wide blanket of impervious material extending to rock.

ESTIMATED QUANTITIES

Clearing and Grubbing – 69 Acres

Stripping Topsoil (1.0') – 111,000 Cu. Yd's

Common Excavation – 1,839,000 Cu. Yd's

Random Fill – 566,000 Cu. Yd's

Impervious Fill – 115,000 Cu. Yd's

#2A Crushed Aggregate - 1,550 Cu. Yd's

Guardrail - 8,300 Lineal Feet

REFERENCE TITLE	NUMBER
ASH STORAGE AREAS #4 & #5 - PLAN	LF-75333
ASH BASIN #6 & POLISHING POND-OUTLET WORKS & HEADWALL	D-158185
ASH BASIN #7 - PLAN & SECTIONS	E-157640
ASH BASIN #6 - LOCATION & LOG OF CORE DRILL HOLES	D-129687

REFERENCE TITLE	NUMBER
BILL OF MATERIAL	A-159148

NO.	DATE	ER.	REVISION	BY	CH.	APPROVED	
4	11/26/07		ADDED REFERENCE NOTE TO SECTION G-G	DM		GDH	
3	11/20/06		ADDED NOTE TO SECTION F-F	DM		GDH	
2	4/2/80	102713	ADDED IN-LINE STATIC MIXER PIT, DISCHARGE SLUICEWAY, REVISED INV. & LENGTH OF 48"⌀ R.C.P. IN SECT. "F-F", DELETED DETAIL "Y".	G.H.C.	FAC	A.L.M. WJB JAS	JAS
1	6/8/79	102713	REVISED DETAIL "K" AND ADDED DETAIL "Y".	G.H.C.	DPK	A.L.M. JAS	
			ADDED GUARD RAIL & AGGREGATE QUANTITIES & DET. "X".				
			REVISED SECT. "F-F" & CLAY IN SECT. "D-D", "E-E", & "G-G".				

LOC CODE: F H 7 0 — DESCRIPTION: BI ASH BASIN NØ 6 PLAN 2 — SORT: C

ER- 102351
ER-
SCALE- AS NOTED
DATE- 1-23-78
DRAWN- EMB
CHECKED- RCB
LEADER- RCS
APPR'D- NHJ
APPR'D- JAS

BRUNNER ISLAND S.E.S.
ASH BASIN NO. 6 AND POLISHING POND PLAN & SECTIONS

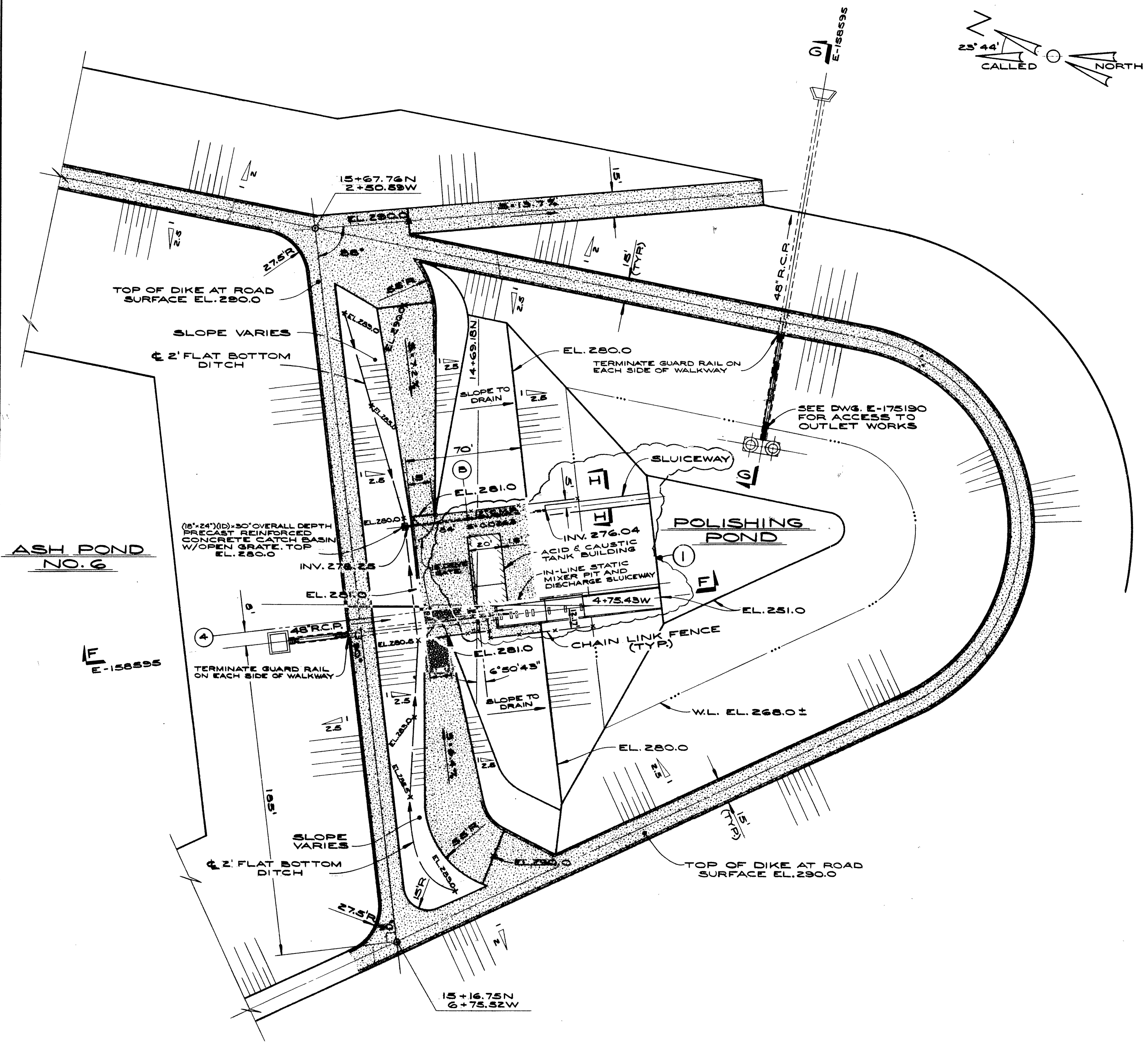
PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA.

SHEET 2 OF 2

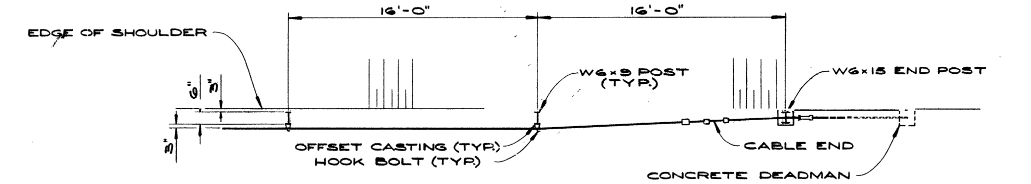
RESPONSIBLE ENGINEER

E158595-4

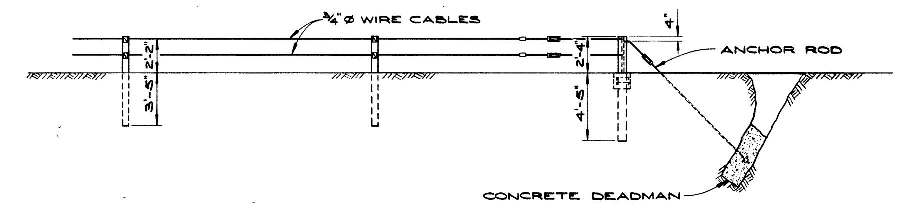
E158595_S2.dwg



PLAN - POLISHING POND
SCALE: 1"=30'

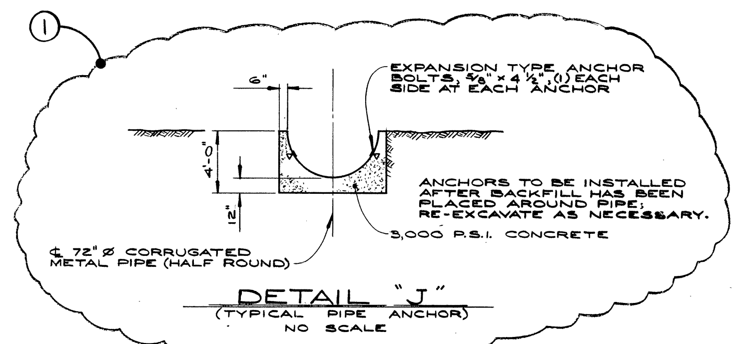


PLAN



ELEVATION

TYPICAL GUARDRAIL DETAIL
NO SCALE

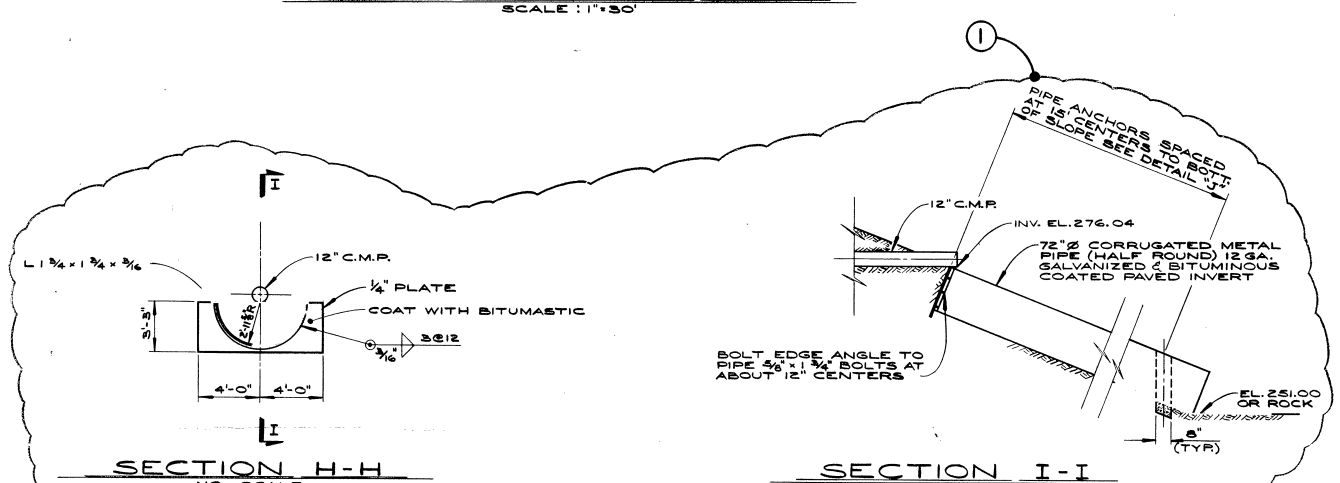


DETAIL "J"
(TYPICAL PIPE ANCHOR)
NO SCALE

6" THICK PENNDOT #2A CRUSHED AGGREGATE

NOTES:

1. ALL FENCE WORK WILL BE IN ACCORDANCE WITH P.P.&L. SPECIFICATION LA 50187.



SECTION H-H
NO SCALE

SECTION I-I
NO SCALE

LIST OF MATERIALS	QUANTITY
15' DRIVE GATE	2
FENCE FABRIC	1,715 S.F.
GATE POSTS	4
LINE POSTS	24
PRECAST CATCH BASIN	1
12" C.M.P.	84 L.F.
72" HALF ROUND	(ON SITE)

REFERENCE TITLE	NUMBER	REFERENCE TITLE	NUMBER
SWITCHYARDS & SUBSTATIONS - PROPERTY FENCE	LD-3886	ASH BASIN #6 - ACCESS TO POLISHING POND OUTLET	E-175190
ASH BASIN #6 & POLISHING POND - OUTLET WORKS & HW.	D-158185		
INLINE MIXER FOUNDATION - PLAN & SECTIONS	D-178075		
ASH BASIN #6 & POLISHING POND - PLAN & SECTIONS	E-158595		

NO.	DATE	ER.	REVISION	BY	CH.	APPROVED
1	4/2/80	102713	ADDED SLUICEWAY TO PLAN, DETAIL "J", & SECTIONS H-H & I-I LOCATED ACID & CAUSTIC TANK BLDG. REVISED FENCE WEST OF BLDG. AND IN-LINE STATIC MIXER PIT & SLUICEWAY.	G.H.C.	FAC	A.L.M.

LOC CODE: F H 7 0
DESCRIPTION: BI ASH BASIN NO 6 ENL PL
SORT: C

W.O. 044712-042

ER- 102713
ER-
SCALE- 1" = 30'
DATE- 6/8/79
DRAWN- G.H.C.
CHECKED- DPK
LEADER- A.L.M.
APPRD-
APPRD-

BRUNNER ISLAND S.E.S.
ASH BASIN NO. 6 - POLISHING POND
ENLARGED PLAN

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA.

APPROVED John A. Stefanik

E-178085-1

PP&L 895-E 34" X 44"
PP&L Letter-Height Drafting Standard: Dwg. No. - 3/8", Title - 3/16", Subtitle - 5/32", Letter figures - 1/8" Min.

ER-DWM-11

PERMIT NO. D 67-496

COPY

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

PERMIT

The Department of Environmental Resources "Department", established by the Act of December 3, 1970 (71 P.S. §510-1 *et seq.*) and empowered to exercise certain powers and perform certain duties under and by virtue of the Act of November 26, 1978, P.L. 1375, No. 325, as amended by the Act of October 23, 1979, No. 70, known as the "Dam Safety and Encroachments Act"; and the Administrative Code, Act of April 9, 1929, P.L. 177, *as amended,* which empowers the Department to exercise certain powers and perform certain duties by law vested in and imposed upon the Water Supply Commission of Pennsylvania and the Water and Power Resources Board, hereby issues this permit to:

PENNSYLVANIA POWER & LIGHT COMPANY
Two North Ninth Street, Allentown, PA 18101

giving its consent to

operate and maintain an existing dam (Ash Basin No. 6) located on Brunner Island between the Susquehanna River and Black Gut Creek in York Haven, York County.

This permit is issued in response to an application filed with the Department of Environmental Resources on the 7th day of April A.D. 19 81, and with the understanding that the work shall be performed in accordance with the maps, plans, profiles and specifications filed with and made part of the application

Subject, however, to the provisions of the Dam Safety and Encroachments Act, the Administrative Code, and the following conditions, regulations, and restrictions (YOUR ATTENTION IS DRAWN TO CONDITION NUMBER 12).

1. This permit does not give any property rights, either in real estate or material, nor any exclusive privileges, nor shall it be construed to grant or confer any right, title, easement, or interest in, to, or over any land belonging to the Commonwealth of Pennsylvania; any infringement of Federal, State, or local laws or regulations; nor does it obviate the necessity of obtaining Federal assent when necessary;

2. The work shall at all times be subject to supervision and inspection by representatives of the Department, and no changes in the maps, plans, profiles and specifications as approved shall be made except with the written consent of the Department. The Department, however, reserves the right to require such changes or modifications in the maps, plans, profiles, and specifications as may be considered necessary. The Department further reserves the right to suspend or revoke this permit if in its opinion the best interest of the Commonwealth will be subserved thereby;

3. The work shall be under the direction of a competent engineer, and he or a competent representative shall be on the ground constantly during construction and until the completion of the dam;

4. The Department shall be notified in advance of the proposed time of commencement of this work, and a detailed report upon the status of the construction shall be mailed to the "Division of Dam Safety, P. O. Box 2357, Harrisburg, Pennsylvania 17120" on the first of each month until work upon the dam has been completed. Within thirty (30) days after the completion of the work authorized

in this permit, the permittee shall file with the Division of Dam Safety, a statement certifying that the work has been performed in accordance with this permit and the approved maps, plans, profiles and specifications. Further, the permittee shall submit to the Division of Dam Safety, within ninety (90) days of the date of final completion of the dam authorized by this permit, a set of "as built" plans for the project;

5. If this work is not completed on or before the N/A day of ______ A.D. 19____. this permit, if not previously revoked or specifically extended, shall cease and be null and void; and if, upon the expiration or revocation of this permit, the work shall not be completed, the permittee shall, at his own expense and to such extent and in such time and manner as the said Department may require, remove all or any portion of the incompleted work and restore the watercourse to its former condition. No claim shall be made against the Commonwealth of Pennsylvania on account of any such removal or alteration;

6. No material shall be placed on any portion of the foundation until such portion of the foundation has been approved, in writing, by a representative of the Department; no earth or other embankment material which is in a frozen condition shall be covered or placed in embankments; concrete shall not be placed in freezing weather except under conditions approved by the Department;

7. The Department shall be notified at least one week in advance of the time when it is proposed to begin to store water in the reservoir or pond created by the dam for which this permit is issued. The Department will require the permittee to allow a portion of the natural stream flow to pass the dam while the reservoir or pond is being filled, and this notice is required in order that arrangements may be made to have a representative on the ground before or during the filling if the Department considers it desirable. Sufficient water to support fish life shall be allowed to flow into the stream below the dam, during the period of its construction or repair and while the reservoir is being filled. The permittee agrees to abide by such rules and regulations as to the storage and discharge of water, and as to the level of the reservoir created by said dam, as may be prescribed from time to time by the said Department;

8. All trees of no value and brush cleared from the area under this permit shall be burned at such time and under such conditions as to prevent the fire from spreading to adjoining timber land; provided, however, that before such burning is begun, the Regional Air Pollution Control Engineer of the Department of Environmental Resources in charge of the Region in which the area is located shall be notified;

9. The permittee agrees in accepting this permit, to install, upon the request of the Pennsylvania Fish Commission, such fishway or fishways as the said Department may require. (See Section 185, of the Act of May 2, 1925, P.L. 448, as amended by Act of April 22, 1929, P.L. 621) Attention is also called to Section 191 of the Act of May 2, 1925, P.L. 448, as amended by Act No. 113, approved May 25, 1935, which provides that no person owning, leasing or maintaining a dam, holding back waters inhabited by fish, shall draw off such waters without first receiving written permission from the Pennsylvania Fish Commission;

10. Performance of the work authorized shall constitute an acceptance of the various conditions contained in the permit; provided; that if the permittee fails to file acceptance of the permit in accordance with Condition 12, the permit becomes null and void and the permittee shall remove all works constructed and restore the area in a manner specified by the Department;

11. The Engineer and the Contractor shall be apprised of all of the provisions and conditions and shall signify their acknowledgement of being so apprised on the form herein attached. Copy of this signed form, together with copy of the permit shall be available for inspection at the project site at all times. Copy of the acknowledgement shall also be forwarded to the office issuing the permit. Failure to have copies of the permit and acknowledgement available for inspection at the project site shall be considered sufficient cause for issuance of a cease and desist order by the authorized Commonwealth personnel;

12. This permit shall not become effective until and unless the permittee shall file with the Department within thirty (30) days from the date thereof, upon a form furnished by the Department, its written acceptance of the terms and conditions imposed therein. Failure to submit such acceptance will render the permit null and void;

13. The permittee is advised that this project may be subject to the regulation of Section 404 of the Federal Clean Water Act of 1977. The permittee is directed to immediately contact the following District Office of the U.S. Army Corps of Engineers for further information:

Chief, Regulatory Functions Branch
U.S. Army Corps of Engineers District
Baltimore District
P. O. Box 1715
Baltimore, MD 21203

14. SEE SPECIAL CONDITIONS ON ATTACHED SHEET.

Date MAR 5 1982

DEPARTMENT OF ENVIRONMENTAL RESOURCES

By: Joseph J. Ellam

Joseph J. Ellam, Chief
Division of Dam Safety

COPY

ATTEST: Cody Leidt

PENNSYLVANIA POWER & LIGHT COMPANY

By: E. H. Seidler

Permittee (signature)

E. H. Seidler
V.P. Engineering & Construction SP&E

SPECIAL CONDITION

The permittee is required to submit annual reports regarding the condition of the dam, certified by a registered professional engineer, to the Division of Dam Safety on or before October 1 of each year.

TABLE OF CONTENTS (cont.)

FIGURES

APPENDICES

Analysis Procedure for determining the wind induced significant wave H_s and wave run-up using "Freeboard Criteria and Guidelines for Computing Freeboard Allowances for Storage Dams", USBR, 1981.

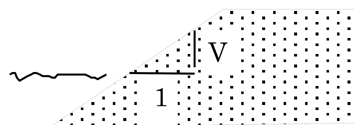
This procedure assumes that site specific wind data are not available, therefore, use the generalized fastest mile and 1-hour maximum winds from Figures 1 to 8 in above Reference. Use 80% of maximum winds for moderate wind condition during Maximum Flood condition.

Project Structures		**NA**	**NA**
Top Elevation w/o camber	290	NA	NA
Slope of u/s face (V >0.2 or 11.3°)	0.4	Vertical	Vertical
U/s Type of Surface	Soil Cement	Concrete	Concrete
General Direction Orientation			

Normal Reservoir Elev. (ft)	286	Assume maximum wind
Maximum Flood Elev. (ft)	288.5	Assume Moderate wind

-06-1609.00-001

Effective Fetch	***Normal***	***Flood***
F_e from Trial and Error (miles)	0.13	0.13
Wind correction Water/Land based on Table 2 & F_e	1.043	1.043



Where: Wind velocity Ratio Land/Water = $1.0301 + 0.098184F_e + 0.0079048F_e^2 - 0.0076136F_e^3 + 0.00085282F_e^4$ with a maximum of 1.30

Meteorological Data

	Figure	Value from Graph (mph)	Normal Pool over water (mph)	Max Flood Pool over water (mph)
Fastest Mile from Figures 1-4 (1 minute)		62	65	52
Season of the year:	Spring			
Fastest Mile from Figures 5-8 (1 hour)		40	42	33
Season of the year:	Summer			
Fastest Mile (2 hour) = 0.96 x (1 hour)		38	40	32

Wind Velocity and Duration Data Points from Figure 9

	Fetch N	***Fetch F***
	0.133	**0.133**

Wind (mph)@ 25' above the water for duration (minutes)

Interpolate Wind velocity values for Normal Pool and Max. Flood Pool from Figure 9 using the appropriate Fetch.

Find at least 5 points and bracket wind velocities found in table above using Figures 1-8.

Values will be used to plot Wind Velocity over Water vs Duration.

See Plots of Normal & Flood

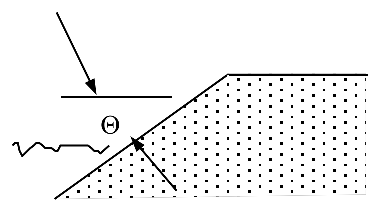
Duration (min)	**Normal Pool over water (mph)**	**Max Flood Pool over water (mph)**
1.0	80.0	80.0
4.0	48.0	48.0
5.0	28.0	28.0
6.0	18.0	18.0
7.0	13.0	13.0
8.0		
9.0		
10.0		
15.0		
20.0		
25.0		
30.0		
40.0		
50.0		
60.0		
70.0		
80.0		
90.0		
100.0		
120.0		
140.0		
160.0		
180.0		
200.0		

	Normal	***Flood***
From Figure 9, determine the significant wave height H_s =	1.1	0.85
From USBR page 15, for Normal Freeboard, Modify H_s to account for average of highest 10% of waves = 1.27 x H_s =	**1.4**	

Calculate Wave Runup and Wave Setup

	Normal		Flood
From USBR Fig. 10, Determine the	1.7	seconds	1.55
From USBR Eq. 2, the wave length L =	**14.8**	feet	**12.3**
$L = 5.12 * T^2$ assumes deep water conditions where the reservoir depth is greater than 1/2 L =	7.4	feet	6.2

	Earth Dam	
Average Pool depth, D @ Central Radial (ft)	26	
Is D > L/2 to ignore bottom effects?	*YES*	
U/s surface slope	0.4	
Angle (deg) of u/s face of dam with the horizon Θ > 11.3°	21.80	***OK***
Cot Θ =	2.50	



Eq. 3 Runup for Significant Wave Height " Rs " (ft)

	Normal	*Flood*		
Riprap	**1.4**	**1.0**		
Correction for Angle Offset if direction of wave propagation is not normal to the embankment	**1.4**	**1.0**	Angle (degrees) (1<α<50)	1
From USBR pg. 13, Earth dam w/ smooth face. (Factor <1.5)			Smooth Face Correction Factor	1.2

Not a Rockfill Dam

Eq. 4 Wind Setup " S " (ft) For:

From Plotted graph of Wind Velocity over water vs Duration	Velocity (mph)	Duration (minutes)
Normal Pool	64.1014438	2.49048964
Flood Pool	50.8958757	3.72851166

Normal Pool

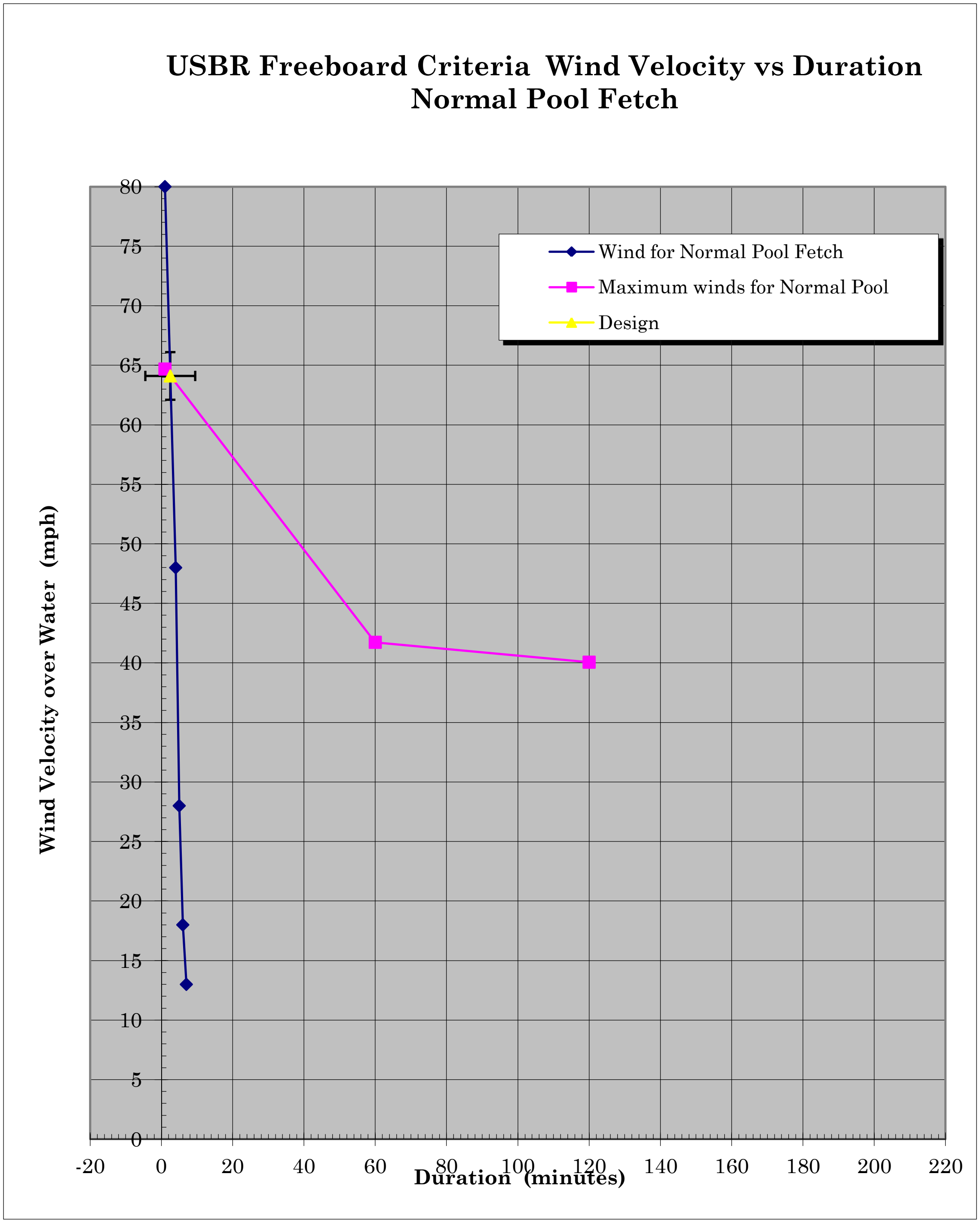
Setup = **0.03** feet

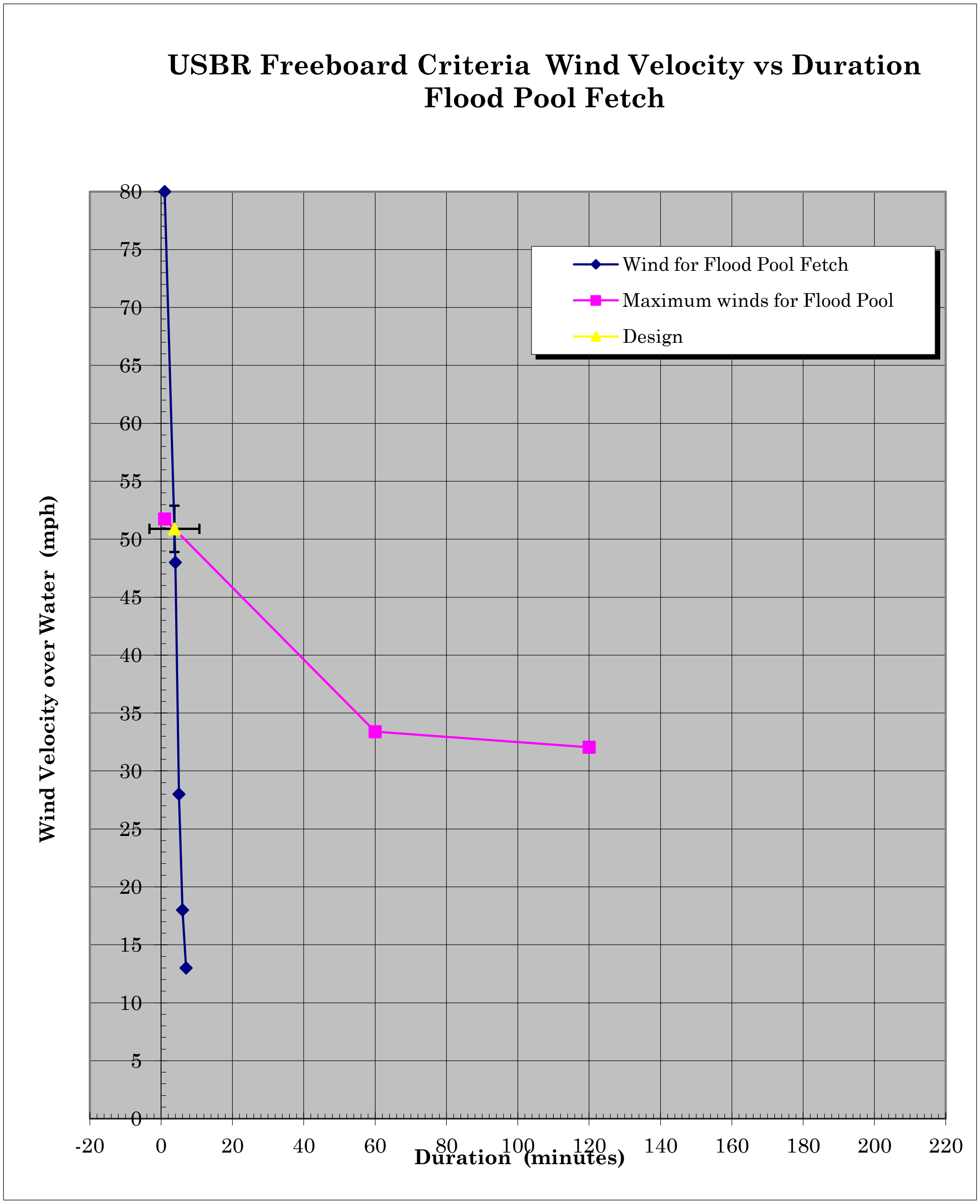
Flood Pool

Setup = **0.02** feet

Minimum Freeboard Requirement (feet)

	Earth Dam
Normal Pool	**1.46**
Req'd Design Dam Crest Elevation	**287.5**
Required < Available ?	OK
Flood Pool	**0.98**
Req'd Design Dam Crest Elevation	**289.5**
Required < Available ?	OK


USBR Freeboard Criteria Wind Velocity vs Duration
Normal Pool Fetch
Wind for Normal Pool Fetch
Maximum winds for Normal Pool
Design
Wind Velocity over Water (mph)
Duration (minutes)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
-20
0
20
40
60
80
100
120
140
160
180
200
220


USBR Freeboard Criteria Wind Velocity vs Duration
Flood Pool Fetch
Wind Velocity over Water (mph)
Duration (minutes)
Wind for Flood Pool Fetch
Maximum winds for Flood Pool
Design
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-20
0
20
40
60
80
100
120
140
160
180
200
220

Calculate the effective fetch, Fe, from existing topographic map of project. Construct a central radial and 7 radial lines at 6 degree intervals on each side. Draw the central radial from a point on the face of the dam to a point on the opposite shoreline in the direction to yield the longest distance over open water.

Radial Number	Angle α	Cos α	$\cos^2 \alpha$	X_i scale distance (ft)	$\cos^2 \alpha * X_i$
1	42	0.7431	0.5523	781	431.32
2	36	0.8090	0.6545	779	509.86
3	30	0.8660	0.7500	785	588.75
4	24	0.9135	0.8346	799	666.82
5	18	0.9511	0.9045	823	744.41
6	12	0.9781	0.9568	859	821.87
7	6	0.9945	0.9891	907	897.09
8	0	1.0000	1.0000	971	971.00
9	6	0.9945	0.9891	920	909.95
10	12	0.9781	0.9568	975	932.85
11	18	0.9511	0.9045	841	760.69
12	24	0.9135	0.8346	816	681.01
13	30	0.8660	0.7500	478	358.50
14	36	0.8090	0.6545	191	125.01
15	42	0.7431	0.5523	116	64.06
		Σ 13.5109		Σ 11041	9463.19

Effective Fetch (F_e) = 700.41 ft.

Trial 1 or **0.13** miles

Check (F_e) = 0.14 miles

Calculate the effective fetch, Fe, from existing topographic map of project. Construct a central radial and 7 radial lines at 6 degree intervals on each side. Draw the central radial from a point on the face of the dam to a point on the opposite shoreline in the direction to yield the longest distance over open water.

Radial Number	Angle α	Cos α	$Cos^2 \alpha$	X_i scale distance (ft)	$Cos^2 \alpha * X_i$
1	42	0.7431	0.5523	781	431.32
2	36	0.8090	0.6545	779	509.86
3	30	0.8660	0.7500	785	588.75
4	24	0.9135	0.8346	799	666.82
5	18	0.9511	0.9045	823	744.41
6	12	0.9781	0.9568	859	821.87
7	6	0.9945	0.9891	907	897.09
8	0	1.0000	1.0000	971	971.00
9	6	0.9945	0.9891	920	909.95
10	12	0.9781	0.9568	975	932.85
11	18	0.9511	0.9045	841	760.69
12	24	0.9135	0.8346	816	681.01
13	30	0.8660	0.7500	478	358.50
14	36	0.8090	0.6545	191	125.01
15	42	0.7431	0.5523	116	64.06
	Σ	13.5109	Σ	11041	9463.19

700.41 ft.

Trial 2 or **0.13** miles

0.14 miles